Research Report
KTC-02-06/KH40-02-1F

KENTUCKY TRANSPORTATION CENTER

College of Engineering

EXPERIMENTAL MAINTENANCE PAINTING ON VARIOUS BRIDGE PROJECTS

Kentucky Highway Investigative Task 40

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Kentucky Transportation Center
176 Raymond Building
University of Kentucky
Lexington, Kentucky 40506-0281

(859) 257-4513
(859) 257-1815 (FAX)
1-800-432-0719
www.engr.uky.edu/ktc
ktc@engr.uky.edu

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Experimental Maintenance Painting on Various Bridge Projects

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By

Theodore Hopwood II
Associate Engineer III, Research

Sudhir Palle
Associate Engineer Senior, Research

And

Rick Younce
Engineer Technician

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

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Kentucky Transportation Cabinet
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EXECUTIVE SUMMARY

The Kentucky Transportation Center (KTC) at the University of Kentucky has performed a series of research studies for the Kentucky Transportation Cabinet (KYTC) to monitor various experimental bridge painting projects and conduct investigative work focusing on new paint systems. The research study addressed in this report "Experimental Maintenance Painting On Various Bridge Projects During 1998-2000" Kentucky Highways Investigative Task No: 40 was intended to address experimental projects in fiscal years 1999 and 2000, but was extended to address certain fieldwork and KYTC inspections through December 31, 2000.

KTC/KYTC Paint Team joint efforts in late 1998 into early 1999 centered on the preparation of experimental bridge maintenance painting special notes, preliminary field testing/development of new experimental paint systems and testing of proprietary and KYTC standard specification coatings. The laboratory tests identified candidate coatings systems that were subsequently used in the KYTC experimental bridge maintenance painting projects conducted under this study. Developmental work focused on micaceous iron oxide (MIO) pigmented moisture-cure polyurethane intermediate coatings, organic zinc moisture-cure polyurethane primers and quick-curing moisture-cure polyurethane coatings (primers and top coats) for rapid deployment painting.

The objectives of experimental project monitoring were to: assess the condition of the existing paint on bridge prior to maintenance painting, monitor the project throughout completion, note problems, describe problem resolution, appraise the condition of the final product, and report observations on/conclusions about the project.

This report will begin with a summary of the coatings testing work undertaken by KTC researchers and the KYTC Paint Team. The experimental bridge maintenance painting monitoring work is presented for each bridge in the appendices. The overall results/findings of this research study are contained in the "Conclusions" section of this report.

INTRODUCTION

Background

Over the past decade, Kentucky Transportation Cabinet (KYTC) bridge painting operations have been significantly impacted by a multitude of regulations from resource agencies. They have been under close scrutiny by both enforcement personnel and the public. Public environmental concerns are driving increasingly more stringent regulations and bridge painting requirements. All of those factors are combining to make bridge-painting operations more expensive from both the first- and life cycle cost standpoints.

Since the early 1990s, KYTC officials directly involved with bridge painting operations (both new and maintenance painting) have sought cost-effective bridge painting practices that complied with environmental and worker safety regulations. Over that period, Kentucky Transportation Center (KTC) researchers have provided assistance in identifying pertinent regulations and necessary actions for compliance. Both parties worked closely to identify cost-effective painting processes (focusing on overcoating) and coatings that performed successfully. Since then, the scope of technical demands posed by bridge painting has increased requiring that additional KYTC personnel from other divisions become more actively involved.

Currently, the Paint Team is composed of KYTC personnel from the Divisions of Operations, Construction, Materials, Employee Safety and Health, and Environmental Analysis and researchers from the KTC Environmental Section. KYTC personnel from the Employee Safety and Health and Environmental Analysis Divisions address issues within their technical oversight. While representatives of the other KYTC Divisions and KTC exercise authority in their respective areas, they cooperate openly in exchanging ideas and opinions that cut across all issues related to bridge painting. The Paint Team uses consensus-based decision-making on the bulk of the issues they address.

The Paint Team employs an incremental improvement approach to gradually implement changes, and hopefully enhancements, in the bridge painting process. Proposed changes are the result of observations of previous bridge painting projects, laboratory or field research, information from outside parties, and Paint Team “brain storming” sessions. Changes involving processes (i.e. cleaning, application, containment, contract procurement etc.) are typically introduced on small field trials. Changes involving materials are typically first analyzed in laboratory accelerated coatings tests. Those appearing to be satisfactory are typically introduced as experimental coatings on subsequent bridge painting projects. KTC researchers typically monitor those projects, evaluating the performance of the experimental features. Those findings are subsequently shared with the entire Paint Team that makes a group decision on whether to employ the features on future bridge painting projects. The benefits of that approach are:

- A continual emphasis on improvements,
- A mechanism to rapidly implement change in a field (bridge painting) subject to major impacts from regulation and technical innovation, and
- The reduced potential for a negative project outcome if an experimental feature does not perform as anticipated.

Paint Team members usually cooperate in developing project special notes during meetings designated for that purpose. Large projects may require several meetings to address all necessary topics and provide mutually acceptable special note wording. Also, decisions are made as to the need for special pre-bid meetings or contractor partnering.

Paint Team Evolution of Bridge Maintenance Painting

The Paint Team has constantly endeavored to enhance all facets related to bridge painting and to provide substantial benefits to KYTC. During the early to mid 1990s, in the face of rising bridge maintenance painting costs, that focus was centered on developing bridge painting practices emphasizing low first costs. At that time, compliance with environmental and worker safety regulations were dealt with by the use of non-invasive painting procedures. While that approach worked satisfactorily on some projects, the poor condition of existing coatings on many KYTC bridges eventually mandated the incorporation of extensive surface preparation requirements to achieve satisfactory projects. Unfortunately, more extensive surface preparation increased the potential for environmental and worker safety impacts. Implementation of those changes resulted in better, more durable overcoating projects, but at higher costs. Those costs drove the Paint Team to become more concerned with life cycle costs and contractor quality.

In recent years, Paint Team efforts have been directed at achieving fundamental bridge painting process improvements. The Paint Team concentrated on creating coatings systems and application protocols that would provide high-quality painting projects. The intent was to improve coatings life-cycle performance (regardless of method of application) particularly for maintenance projects.

Under this arrangement, KTC researchers have performed a series of research studies to monitor experimental bridge painting projects and conduct investigative work focusing on new, environmentally compliant coatings systems for bridge applications. This report addresses research conducted under Kentucky Highways Investigative Task No: 40, “Experimental Maintenance Painting On Various Bridge Projects During 1998-2000.”

That study was intended to investigate experimental projects beginning in FY 1999 (beginning in July 1, 1998) and ending in FY 2000 (June 30, 2000). Due to the Cabinet’s efforts to let a number of large-scale projects in 1999, no experimental bridge painting projects were let in 1998. Paint Team efforts in late 1998, extending into early 1999, centered on development of those specifications and the investigation of new experimental paint systems both by laboratory and, subsequently, by experimental bridge maintenance painting projects conducted under this study. This study was actually covers experimental projects begun in the 1999 and 2000 calendar years. The study was extended until December 31, 2000 to allow monitoring of certain experimental bridge maintenance painting projects initiated earlier in the year.

In the fall of 1999, the Paint Team prepared a five-day Qualified Persons for KYTC Coatings Inspection Course. The course was mandated for persons employed as QC inspectors working on bridge maintenance painting projects. Both contractors and coatings consultants provided candidates for this course that was initially offered in March 2000. The curriculum addresses safety training, bridge cleaning and surface preparation (methods and inspection), waste handling and disposal, and paint application (methods and inspection). The training includes classroom instruction and hands-on training. The students are required to pass written and practical tests to be officially qualified to be QC inspections on KYTC bridge-painting projects. Thereafter, the individual must take an abbreviated refresher course every two years to maintain their qualifications. The Special Notes for the experimental projects performed under this study required that contractors have QC inspectors to oversee the work. The experimental projects conducted under this study required many of the same items/tasks required in subsequent projects using Qualified QC inspectors. However, the formal training was not required, nor was it mandated for KYTC QA inspectors. That may have had a significant impact on the quality of some projects completed under this study.

EXPERIMENTAL COATINGS TESTING

Early Coatings Evaluation Work

Over the past ten years, a significant portion of Paint Team work has been conducted on identifying/developing new bridge coatings systems. Those coatings are primarily intended for bridge maintenance painting as part of the KYTC overcoating program. Initial performance tests performed between 1991 through 1997 were of proprietary and KYTC compositional specification coatings systems subjected to normal atmospheric exposure. That work included test patches applied on scrap steel at the KYTC bridge yard, test patches applied to in-service bridges, and more importantly, projects that included complete bridge overcoating projects using experimental coating systems and application methods.

While that approach to testing provided valuable information, it presented a number of disadvantages in terms of coating evaluation. To obtain useful coatings performance data, KYTC and KTC personnel often had to wait several years to obtain significant results. Also, coatings performance on experimental overcoating projects was impacted by the initial condition of bridges (e.g. existing paint and extent of corrosion) and by painting contractor quality.

Laboratory Performance Testing

In 1994, KTC acquired QUV and Prohesion test chambers to conduct accelerated weathering and corrosion tests, respectively, on standard and experimental paint systems. That effort was part of a previous study to: 1) investigate the possibility of correlating accelerated laboratory tests with field results and 2) screen coatings for follow-on testing in experimental bridge overcoating projects.

An initial series of QUV/Prohesion tests were conducted in 1994-95 to investigate proprietary coatings systems for overcoating and new construction. Cyclic freeze-thaw tests were improvised during those tests by periodically placing the test panels in a commercial freezer for a set time period and subsequently extracting them for room temperature thawing in the test laboratory.

For those tests, coatings manufacturers supplied KTC with painted steel test panels. Prior to testing, KTC researchers scribed the panels with a Tooke cutter and measured the thicknesses of the respective coatings to ensure that they conformed to manufacturer specifications.

The test panels were hot-rolled steel plates measuring 6 inches by 4 inches by 3/16-inches thick. That panel size has become the standard for all KTC laboratory tests. Overcoating systems were to be applied over panels with “as furnished” millscale surfaces. New construction coatings were to be applied over panels with blast-cleaned surfaces prepared to the manufacturer’s specifications. Although the manufacturers received the requests for painted panels at the same time, there was a considerable variation in the delivery dates of the panels between the manufacturers. As a consequence, KTC researchers assumed that there was a significant difference in the cure times for the coatings systems between manufacturers.

The initial KTC laboratory tests were performed without incident. The tests were run for 100-hr intervals in QUV and Prohesion test chambers, with KTC personnel manually rotating the test panels between chambers. After a 1,000 hrs of testing, the panels were subjected to 10 freeze-thaw cycles conducted over a five-day period followed by measurements of percent rust and blistering, gloss, and scribe undercutting. The tests were completed after 3,000 QUV/Prohesion test hours.

The results of the initial tests indicated that millscale panel finishes were probably not desirable coatings substrates as considerable scribe undercutting occurred on all overcoating systems. Cathodic disbonding was a suspected source of the problem. The duration for the tests (3,000 total hours) was found to be too brief to cause significant deterioration of most new construction coatings. There was also a concern that variations in cure times between the various coatings systems impacted the test results.

After these initial tests, the Paint Team sought to: 1) better utilize the laboratory coatings performance tests and 2) eliminate test variability that impacted the first set of laboratory tests. They also wanted to investigate a number of different coatings ranging from modifications of the KYTC Standard Specifications to proprietary coatings. Coatings that performed successfully in the laboratory tests would be used in follow-on experimental bridge overcoating projects. If field tests proved successful, generic coatings systems would be adopted as KYTC specification standards and proprietary ones would be placed on a qualified products list.

In planning the second round of accelerated coatings tests (1998), the Paint Team implemented several changes. The experimental coatings were to be applied by KTC researchers after the Division of Materials initially analyzed and characterized wet samples provided by manufacturers. That would allow KTC researchers to better regulate the cure times and other application variables. The test duration was to be extended until significant differences in performance were observed between coatings systems. The Kentucky Transportation Cabinet standard coating system (two coats aluminum-pigmented moisture-cure polyurethane and one coat of two-component aliphatic polyurethane) was to be used as the reference standard for all future tests. The panel application surface finish for overcoating systems was changed from mill scale to rust. A single supplier provided the panels meeting an SSPC Grade D visual rust finish per SSPC-VIS 1. The panels were stamped on their backside with consecutive numbers to facilitate correlation with specific coatings systems. All of the coatings tested in the second round were intended for overcoating applications.

Several steps were taken to facilitate testing. The test intervals in each chamber were extended to 7 days (168 hours) simplifying the shifting of test panels between chambers. The cyclic freeze-thaw test was automated by adding an environmental chamber with temperature and humidity regulation capabilities. A freeze-thaw test protocol developed reflecting coating service conditions in Kentucky (See Below).

Two manufacturers supplied coatings systems for the tests. Manufacturer M1 provided 6 coatings systems including the KYTC specification standard to be used as a control coatings system (See Table I). Manufacturer M2 provided 5 coatings systems (See Table II).

As mandated by the Paint Team, the Division of Materials personnel sampled the coatings and performed laboratory tests to assure that they conformed to manufacturer and/or KYTC specifications. That work was completed prior to coatings application to ensure that the applied/tested coatings conformed to either the manufacturer or KYTC standards.

The capacities of the KTC laboratory test equipment limited the number of coatings tested and also the number of panels of each coating type. To achieve high confidence in the test results, each experimental coating system was applied to fifteen panels. Those with application flaws were discarded and the best 10 panels for each coatings system were tested. Based upon capacities of the KTC test equipment, the tests consisted of two sequential runs of 6 coatings systems each. The KYTC standard system was used as the control system in each test run.

The coatings of manufacturer 'M1' were applied at his plant while those of manufacturer 'M2' coatings were applied at the University of Kentucky Physical Plant (Figure 1). Prior to application, measurements were taken of environmental conditions to ensure conformity with manufacturer requirements. A prime coat was applied to both faces of the panels. Thereafter, only the test side of the panels received additional coats of paint. All coatings were applied by brushing with a 24-hour curing period between coats. Brushing was used because it was commonly specified by KYTC or employed by paint contractors for use in unconfined bridge maintenance painting work. During painting, frequent wet film measurements were taken using tooth gages to ensure that the dry-film coating thicknesses would be within manufacturer requirements.

The painted panels were cured for 30-35 days at room temperature and humidity prior to the onset of laboratory testing. Prior to testing, the coupons were photographed and a 2-inch scribe mark was placed near one 6-inch edge of the panels using a Tooke cutter (Figure 2). A Tooke gage was used for preliminary dry-film thickness measurement of each coat of paint. Measurements were taken of the initial gloss using a 60^{o} gloss meter in conformance with ASTM D523. Due to the use of brush application, there was a wide variation in the gloss readings on each specimen. This impacted the relevance of gloss data acquired during the tests. The laboratory performance tests incorporated accelerated weathering (cyclic UV/humidity-QUV), corrosion (cyclic condensation/evaporation-Prohesion) and accelerated environment (cyclic freezing & thawing/humidity) in a controlled environmental test chambers.

The QUV light condensation chamber was used for the accelerated weathering test. Normal tap water was used in this test. A test cycle consisted of a four-hour UV exposure cycle with UVA-

340 lamps set at normal irradiance at 60^{o} C alternated with a four-hour condensation cycle at 50^{o} C (Figure 3).

Prohesion tests were performed in a cyclic corrosion test chamber. The test employed an electrolyte solution of deionized water, 0.05% sodium chloride, and 0.035% ammonium sulfate (Figure 4). The Prohesion cycle consisted of a one-hour fog application of the electrolyte followed by a one-hour dry off period. Prohesion tests were performed at room temperature (approximately 20^{o} C).

The Paint Team developed the cyclic freeze-thaw test. A freeze-thaw chamber with humidity control was employed for that test (Figure 5). Hourly temperature data from KYTC bridges indicated that they experienced about 60 freeze-thaw cycles annually. However, the average temperature range of those cycles only varied from about $+3^{o}$ C to -3^{o} C. Freezing of coatings in a water-saturated condition was possible. To replicate that exposure, the freeze-thaw cycle test consisted of a one-hour exposure at $+3^{o}$ C at 90 percent relative humidity followed by a one-hour ramp down of the temperature to -3^{o} C at 0 percent humidity (Figure 6). Those conditions were maintained for one hour followed by a one-hour ramp up to $+3^{o}$ C at 90 percent humidity. This test design emphasizes a large number of freeze-thaw cycles at small temperature excursions above and below freezing. That minimizes the potential for thermally shocking the applied coatings.

The tests were conducted in the previously described sequence. Panels were exposed for one-week periods (168 hours) and then shifted to the following test chamber for the next test. The tests were stopped at 6-week intervals (1,008 hours) to examine the panels and take necessary measurements and photographs (Figure 7). Measurements were taken of gloss (ASTM D-523), blistering (per ASTM D-714), scribe undercutting (per ASTM D-1654), and rust-through (per ASTM D-610).

The tests were run for seven 6-week intervals (7,056 hours). In part, the extended duration of those tests was due to the desire of KYTC and KTC personnel to gain familiarity with the procedure. No endpoints for coatings failure were established. Typically, the coatings on the panels possessed significant degradation after 7,056 hours of testing (Figure 8).

The resulting laboratory data, percent rust, scribe undercutting and percent gloss were correlated versus test durations (Figure 9). Normally, percent blistering is also included in the data. However, no blistering was encountered during the test on any coatings system. As the KYTC control system was the accepted standard for acceptable performance, the test results of the other paint systems were normalized to the results obtained with the control system (Figures 10-15). KYTC and KTC personnel reviewed the data and identified the coatings systems that performed satisfactorily. Plans were made to conduct experimental overcoating projects on several KYTC bridges using those systems in the fall of 1999.

Acceptance Testing by the KYTC Division of Materials

A key component of the Paint Team’s coating research is laboratory coatings characterization and subsequent field sampling/acceptance testing conducted at the KYTC Division of Materials.

The Division of Materials laboratory quality assurance (QA) testing program consists of a material's chemical and physical evaluation performed in conjunction with the KTC accelerated weathering/corrosion performance evaluation. Manufacturers must submit an initial qualification sample of their system to the Division of Materials for evaluation. Those sample coatings are subjected to a variety of tests to physically characterize them and ascertain that they possess certain properties that are characteristic of good coatings. Acceptable coatings must possess properties that fall within their manufacturer's standards (e.g. unit weights, volume of solids, VOC content) or KYTC specifications [including resin NCO content, hindered-amine content (for aliphatic polyurethane topcoats), and MEK double-rubs]. Infrared fingerprinting is conducted on both types of coatings systems.

Once a system has passed the initial quality assurance tests and has subsequently proven to perform satisfactorily (in laboratory and field performance tests), it will be placed on a list of approved materials maintained by KYTC at the Division of Materials. Painting contractors must use systems that appear on the list of approved materials or that are specified in project special notes.

After a manufacturer has an approved system and has been selected to supply coatings for a project, KYTC personnel will randomly sample each batch delivered to a job site. The Division of Materials will evaluate the samples for chemical and physical conformance to the manufacturer's standards or KYTC specification. Failure to meet any part of those will result in the rejection and immediate removal of the failing batch of product from the job site. Recently, in conversations with several counterparts in other state highway agencies revealed that the practice of laboratory verification or QA testing is being gradually replaced with the notion of product acceptance based on manufacturer certification.

Paint Team personnel believe a decline in QA acceptance testing will result in poor coatings performance and, consequently, an increase in maintenance costs to the facility owners. Experience has shown that even with the foreknowledge that acceptance testing will be performed, quality oriented paint manufacturers will occasionally supply a batch of a coating that is found to be unacceptable. That reflects the variability inherent in paint manufacture. A supplier with poor quality control or financial incentives to supply non-specification coatings is much more likely to provide nonstandard (i.e. substandard) coatings.

Additional Coatings Investigations

The KYTC Paint Team (including KTC researchers) identified the need for additional new coatings to extend the utility of existing KYTC standard specified coatings (i.e. aluminum-pigmented moisture cure polyurethane primer/intermediate coatings and the acrylic polyurethane topcoat). Work towards developing those coatings was conducted under this study in 1999 and 2000. It involved the development/testing of micaceous iron oxide (MIO) pigmented moisture-cure polyurethane intermediate coatings, organic zinc moisture-cure polyurethane primers and quick-curing moisture-cure polyurethane coatings for rapid deployment painting.

The development of a MIO pigmented moisture-cure polyurethane primer/intermediate coating was prompted by the Paint Team's objective of developing a coating that could be applied under a broader range of conditions than those of the standard aluminum-pigmented moisture cure polyurethane primer/intermediate coat. The Paint Team became involved with several coatings manufacturers that were willing to provide the other KYTC standard specified coatings. One of those firms, Davis-Frost Paint Mfg., developed a coating that was successfully applied on a steel beam the KYTC steel bridge yard in Frankfort in 1999 (Figure 16). Division of Materials personnel developed a draft standard specification for a MIO coating that could be met by Davis-Frost and another supplier. However, prior to laboratory accelerated weathering and corrosion testing, Davis-Frost withdrew from the structural coatings market and only one supplier remained. Thereafter, the Paint Team set aside plans for a KYTC standard MIO coating.

Concurrent with that effort, the Paint Team sought to develop/investigate the use of organic zinc primers. In part, this was prompted by problems encountered with inorganic zinc primers used for new construction (Figure 17). The advantage of organic zinc primers is that they are also suitable for use on maintenance painting projects where total removal/abrasive blasting is employed. In 1999, the Paint Team worked with a local coatings supplier, Environmental Protective Coatings Inc., to develop and test an organic zinc moisture-cure polyurethane primer. Experimental coatings with zinc contents between 80 to 92 percent zinc by weight were first tested in controlled indoor applications (Figure 18). The cured coatings were inspected for surface defects using a video microscope (Figure 19). Thereafter, a field application of an 80 percent organic zinc moisture-cure polyurethane primer was successfully completed on a steel beam at the KYTC steel bridge yard in Frankfort in 2000 (Figure 20). The KYTC Division of Materials opted to prepare a qualified products list of organic zinc primers (including those using resins other than polyurethanes). For a product to be placed on this list, it had to have 1) a certification that the coating had an AASHTO Class B slip coefficient rating, 2) that it had been successfully in service for at least one year, 3) that it had withstood 3,000 hrs of salt fog exposure (ASMT B 117), and 4) that the manufacturer would supply intermediate and top coats that met KYTC standard specifications and were compatible with the primer. Currently, there are two coatings manufacturers supplying organic zinc coatings meeting those requirements.

Rapid deployment painting is a new approach to applying coatings on smaller structures such as overpass bridges where significant potential exists for inconvenience of motorists due to painting operations. To minimize such problems, the rapid deployment method uses special vehicles placed on roadways equipped to quickly contain portions of overpass bridge steel and to permit prompt initiation of painting operations (i.e. cleaning by abrasive blasting, collection of wastes, and painting). In one night, a rapid deployment painting operation is able to complete those operations over one lane-width of the underlying roadway. This work can be performed at nighttime, in off-peak use periods of the roadway, thereby minimizing inconvenience to motorists.

A key feature of this approach is a rapid-cure paint system that can be applied in two full sprayed on coats of paint in a relatively short time interval. To work properly, the coatings, an organic zinc primer and a polyurethane topcoat must cure rapidly and provide sufficient durability to justify the added cost of rapid deployment painting. In 2000, Paint Team personnel contacted state highway agencies in neighboring states that had used the rapid deployment approach and identified issues that needed further development. At the same time, the Paint Team arranged for Bayer Inc. to make a demonstration application of a quick-cure rapid deployment coatings system consisting of an organic zinc moisture cure primer and an acrylic polyurethane topcoat on a steel beam at the KYTC steel bridge yard (Figure 21). After that successful demonstration, a coatings manufacturer, Tnemec, applied a similar system on another steel beam at the bridge yard. KTC researchers will continue to monitor the performance of those applications for several years.

MONITORING OF EXPERIMENTA L PROJECTS

During this study, a total of five experimental bridge overcoating projects were let and completed. Those are described in detail in Appendices A-E below. All of these projects were relatively similar in terms most Special Notes and the general types of structures to which they were performed (i.e., steel girder bridges). The only major variances were the coatings applied, the KYTC Districts/QA inspectors who oversaw the work, and the contractors who performed the work.

The pressure washing for all the projects was to be performed at 7,000 psi using 0^{o} spinner tips. The mechanical surface preparation was to be formed to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3 **Visual Standards for Power- and Hand-Tool Cleaned Steel.** On this project, an SSPC VIS3-SP11 surface condition was specified for mechanically cleaned surfaces. All the coatings systems were based upon MCU primers and intermediate coats and two-component polyurethane and polyester topcoats.

Based upon KYTC Paint Team inspections of the projects, it was determined that two were performed satisfactorily, one was partially acceptable, and two did not conform to the standard specifications and Special Notes. The primary source of that irregular performance was contractor quality. Another factor was that the KYTC did not adequately inspect the work in some cases or that the districts did not compel the contractors in question to adequately complete the projects. Four of those cases, the two acceptable projects and the two non-conforming ones were related to the work of two contractors. One contractor performed good work on both of his projects: the other did not. The third contractor’s work contained numerous small flaws, but they were not sufficiently severe to consider the work unacceptable.

As might be expected, other problems were experienced with the contractor producing the unsatisfactory painting work. That included disposal of hazardous waste and performance of traffic control. Another problem arising out of the poor work is that it does not provide a good yardstick to assess the experimental coatings. Significant effort has been expended in developing the experimental Special Notes and monitoring the projects. It is disappointing when low contractor quality negatively impacts experimental projects as it limits the opportunity to learn about the performance of experimental features.

CONCLUSIONS

Coatings Performance and Acceptance Testing

The KYTC/KTC coatings performance and acceptance testing provides a mechanism for assuring new coatings used on KYTC maintenance painting projects will perform successfully. The testing program is evolving with continued modifications to both test processes. Currently, the testing is used to evaluate coatings used in the next 2-5 years. Future tests will be intended to identify new coatings that will be mandated by more restrictive regulations. That will place KYTC in a proactive position for responding to regulatory changes.

In the future, the Paint Team will investigate new and emerging coating technologies that offer significant performance enhancements over conventional organic coatings. Among the anticipated benefits of the new coatings are more durable coatings, better corrosion resistance, longer gloss and color retention and reduced environmental impacts. The Paint Team will be investigating one and two-coat systems that are contractor friendly and that can be applied over marginally prepared substrates. Those coatings are to be used on bridges on low-volume roads in overcoating applications where the existing paint is typically in very poor condition. Durability and aesthetic considerations are subordinated to ease of application and the likelihood that a suitable end product will be obtained.

Experimental Maintenance Painting Projects

The experimental overcoating projects conducted under this study incorporated detailed requirements for all phases of contractor work. These projects were not inexpensive with the costs ranging from \$2.20 to \$5.50 per ft^2. KYTC officials should have every right to expect uniform acceptable contractor quality on all of the projects. In several instances, KYTC officials encountered both sub-standard workmanship and ineffective site inspection. There are two factors that come into play relative to those projects – KYTC qualification procedures for painting contractors and the attentiveness of KYTC inspectors to their duties. Experience with KYTC painting practices and expectations may also factor in, but education doesn't. The contractor and most of the KYTC inspectors involved attended KYTC qualified paint inspector school prior to working on the projects and were well informed of KYTC specifications, practices, and, possibly, expectations. But, sometimes, expectations have to be experienced rather than learned. Certainly, those parties should have been aware of requirements related to the specification and the work that was to have been provided. It should be noted that the contractor's QC inspector failed the qualification examination for the KYTC QC/QA course.

To a large measure, this issue could have been avoided by not qualifying the contractor. KYTC painting operations have become more demanding of contractor technical expertise in all facets (i.e., practice, documentation, environmental, worker safety and traffic control). Many contractors that could work on KYTC projects in the past can no longer accommodate those demands. As many of those are inexperienced with current KYTC practice, they mistakenly assume that KYTC projects are similar to those conducted in other states or in other industries..

Under the present circumstances, poorly qualified painting contractors can bid on KYTC projects. Based upon statutory law, KYTC is generally obliged to accept the lowest bid. This indicates that KYTC must pay more attention to painting firms wishing to do business with it and restrict the market to those who are technically capable, and willing to provide satisfactory work. With small projects, the bidding intensifies, as more painting contractors are bondable. One obvious solution would be to bundle projects to increase the bonding requirements. In any case more attention must be paid to painting contractor qualifications.

TABLES

Table I. Coatings Systems Supplied by Manufacturer M1		
System Number	Description	Tooke DFT (mils)
1	Primer – Aluminum Pigmented MCU	1-2
	Intermediate – Aluminum Pigmented MCU	1-2
	Top Coat – Acrylic Aliphatic PU	3-5
2	Penetrating Sealer – Red Oxide Pigmented MCU	1.5-3.5
	Intermediate – MIO Pigmented MCU	2.5-5
	Top Coat – Acrylic Aliphatic PU	1.5-3.5
3	Penetrating Sealer – Red Oxide Pigmented MCU	1-2
	Intermediate – MIO Pigmented MCU	3-6.5
	Top Coat – Two Component Polyester	1.5-2.5
4	Penetrating Sealer – Red Oxide Pigmented MCU	1-1.5
	Intermediate – MIO Pigmented MCU	2-7
	Top Coat – Acrylic Aliphatic PU	2-2.5
5	Primer – Aluminum Pigmented MCU	1.5-2
	Intermediate – Aluminum/MIO Pigmented MCU	2-3.5
	Top Coat – Acrylic Aliphatic PU	2-3
6	Penetrating Sealer – Red Oxide Pigmented MCU	2-3.5
	Intermediate – MIO MCU	2.5-5
	Top Coat – Acrylic Aliphatic MIO Pigmented PU	1-2

Legend:
MCU – Moisture cure polyurethane
PU – Two-component polyurethane

Table II. Coatings Systems Supplied by Manufacturer M2		
System Number	Description	Tooke DFT (mils)
1	Primer – Aluminum Pigmented MCU	1-3
	Intermediate – Aluminum Pigmented MCU	1-3.5
	Top Coat – Acrylic Aliphatic PU	4.5-6
2	Penetrating Sealer – Clear MCU	2-4
	Intermediate – Aluminum Pigmented MCU	2-5
	Top Coat – Acrylic Aliphatic PU	1.5-3
3	Penetrating Sealer – Clear MCU	1-2.5
	Intermediate – MIO Pigmented MCU	2-5
	Top Coat – Acrylic Aliphatic PU	3.5-6
4	Single Coat – Zinc Pigmented Alkyd	7-10
5	Primer – Aluminum Pigmented Epoxy	4.5-7
	Top Coat – Acrylic Aliphatic PU	2.5-6

Legend:
MCU – Moisture cure polyurethane
PU – Two-component polyurethane

FIGURES

Figure 1. Acrylic polyurethane top coat being applied at the University of Kentucky.

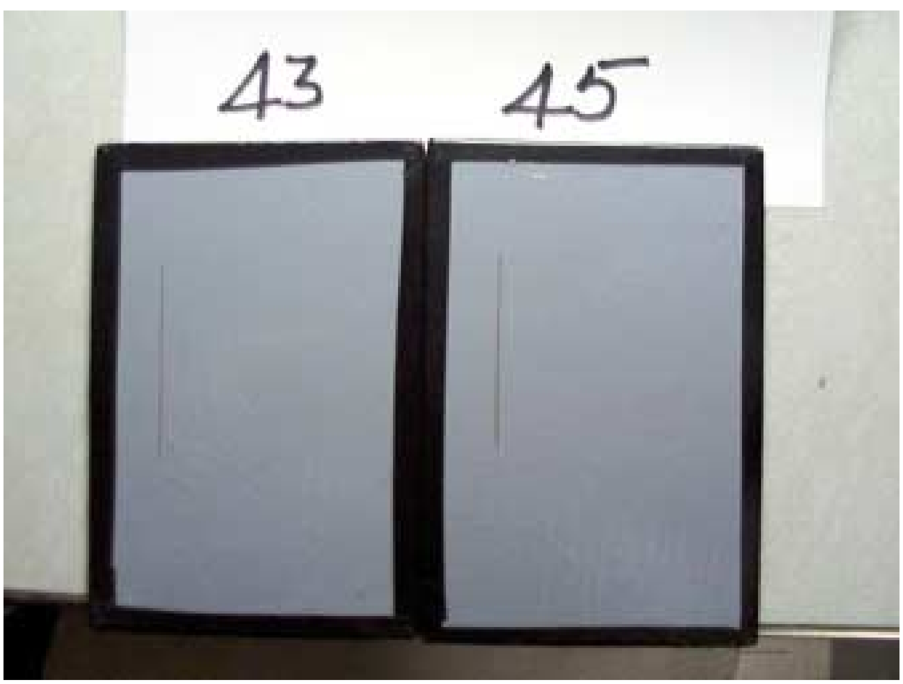

Figure 2. Coated panels with scribe marks and taped edges prior to testing.

F

Figure 4. Tests panels being placed in the Prohesion chamber.

Figure 5. Test panels placed in a rack in the freeze/thaw chamber.

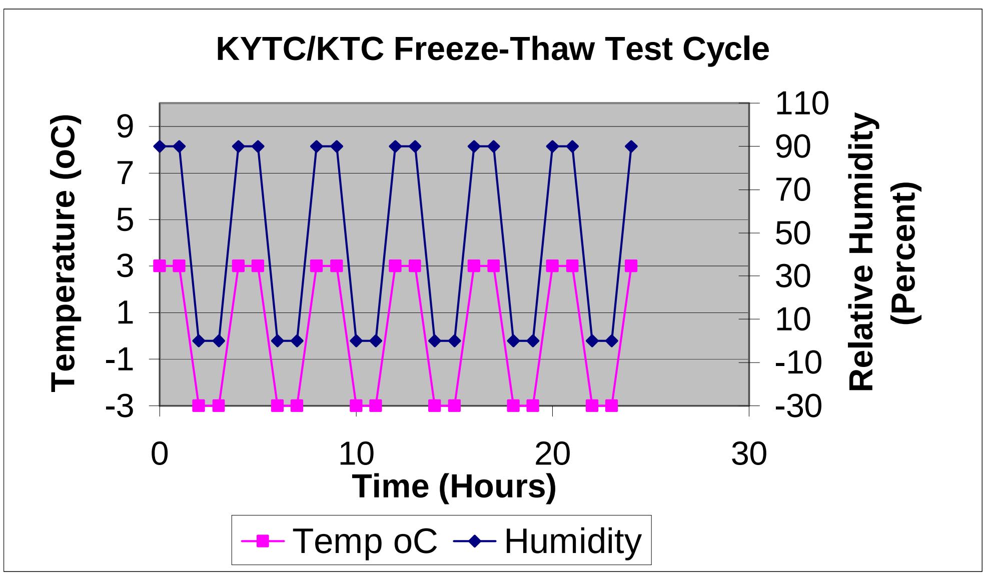

Figure 6. Humidity/temperature cycles for KYTC/KTC freeze-thaw testing.

Figure 7. Panels were evaluated after each 1,008 (6-week) block of testing. A 60^{o} gloss test is being performed in this picture.

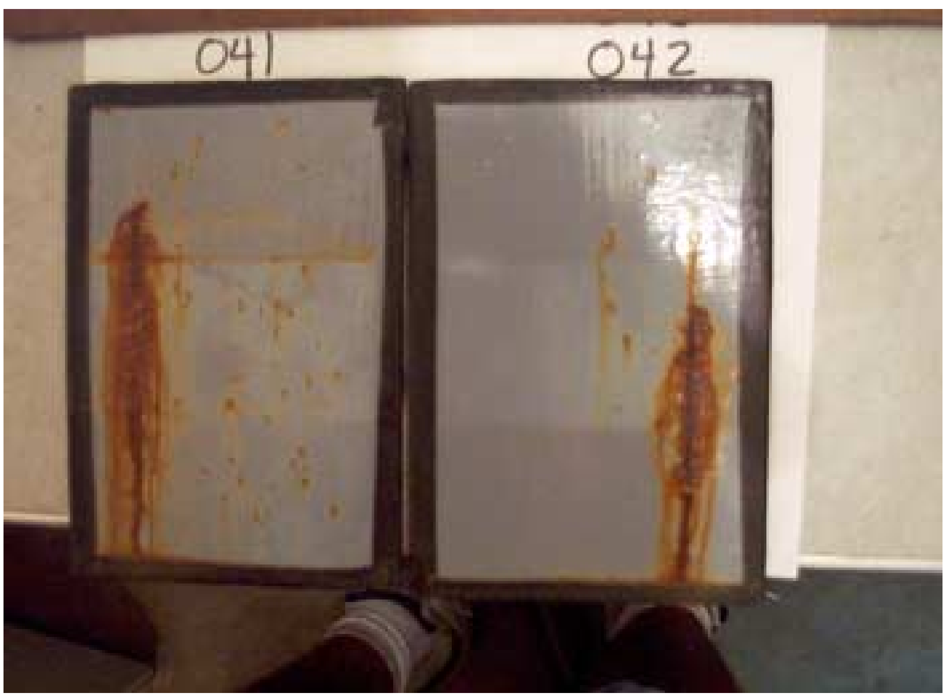

Figure 8. Typical panels after 7,056 hours of accelerated weathering and corrosion testing.

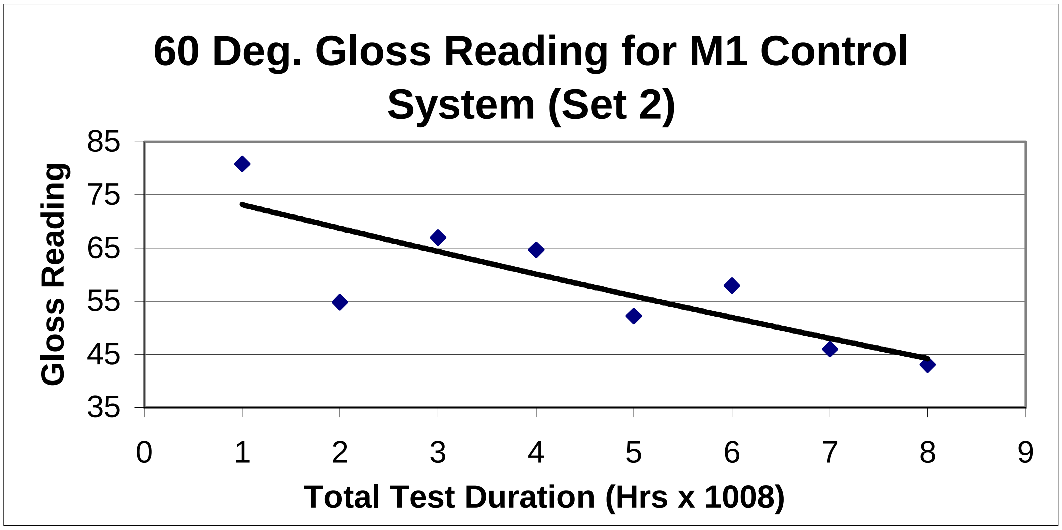

Figure 9. Chart of 60^{o} gloss data of the M1 control system for the entire test.

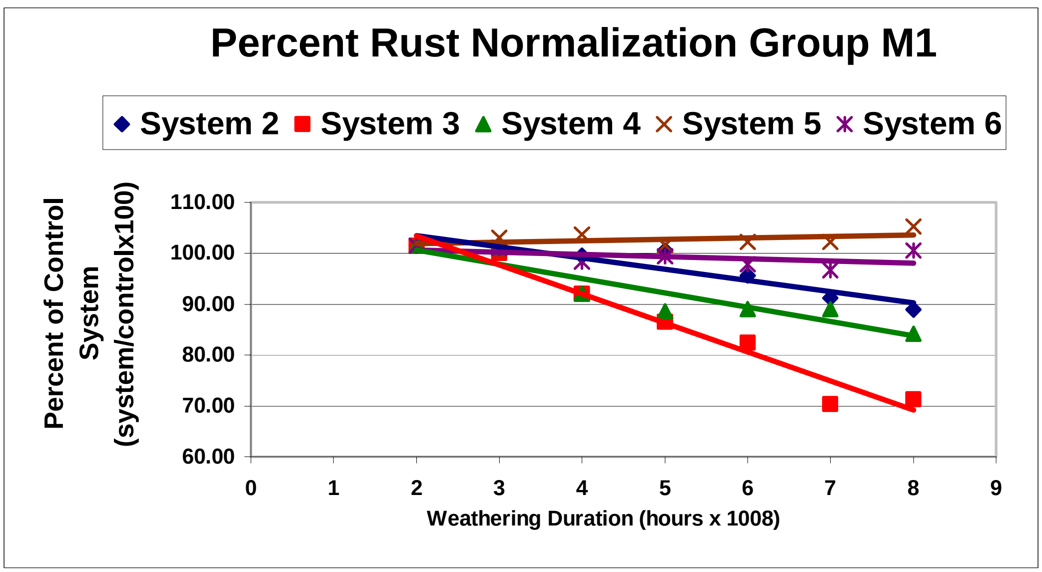

Figure 10. Percent rust normalization curves for coatings systems from manufacturer M1 based upon performance on the control system.

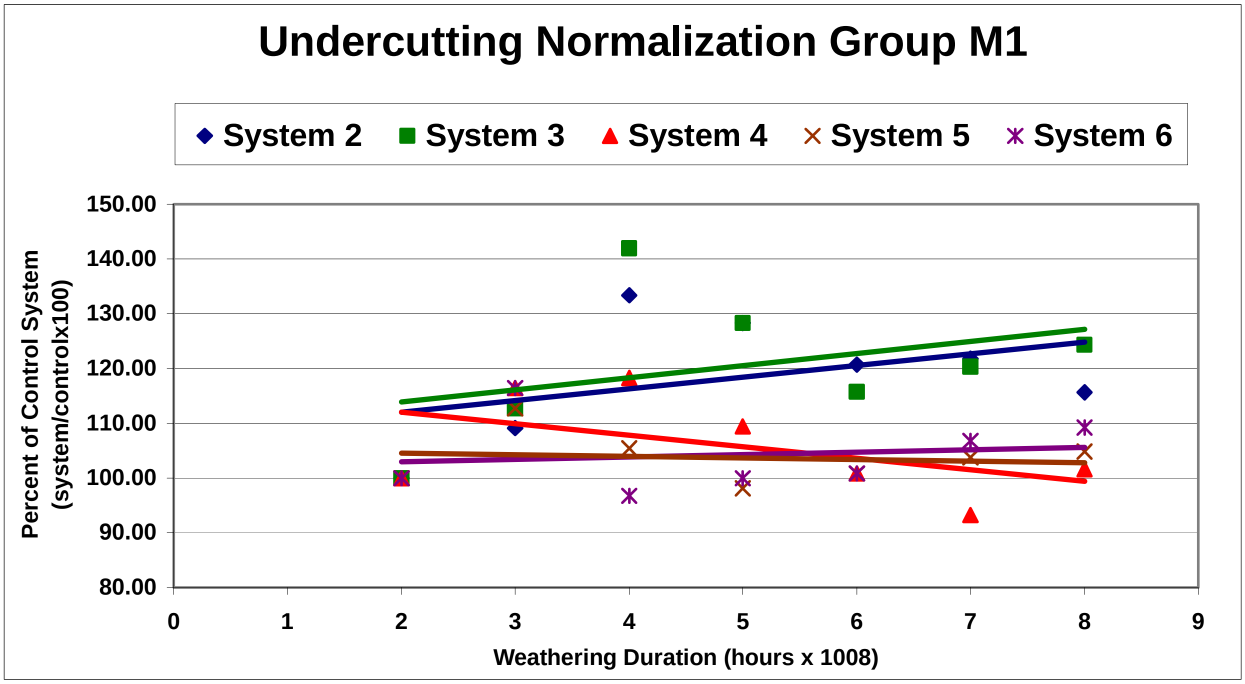

Figure 11. Scribe undercutting curves for coatings systems from manufacturer M1 based upon performance on the control system.

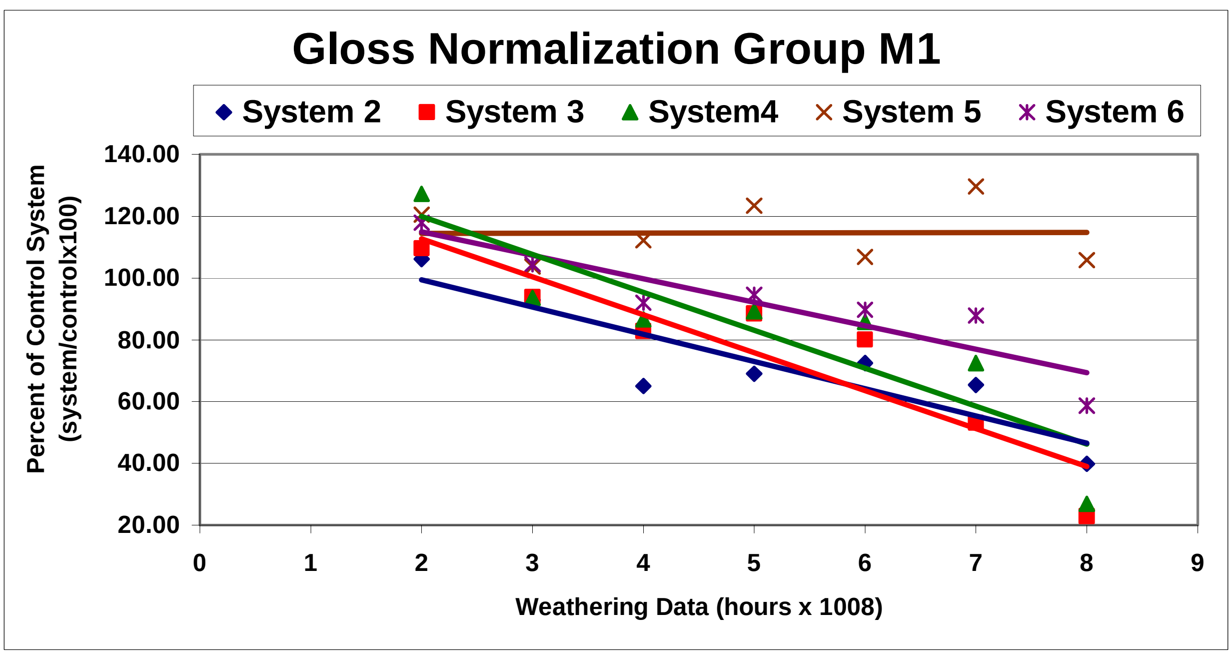

Figure 12. Gloss normalization for coatings systems from manufacturer M1 based upon performance on the control system.

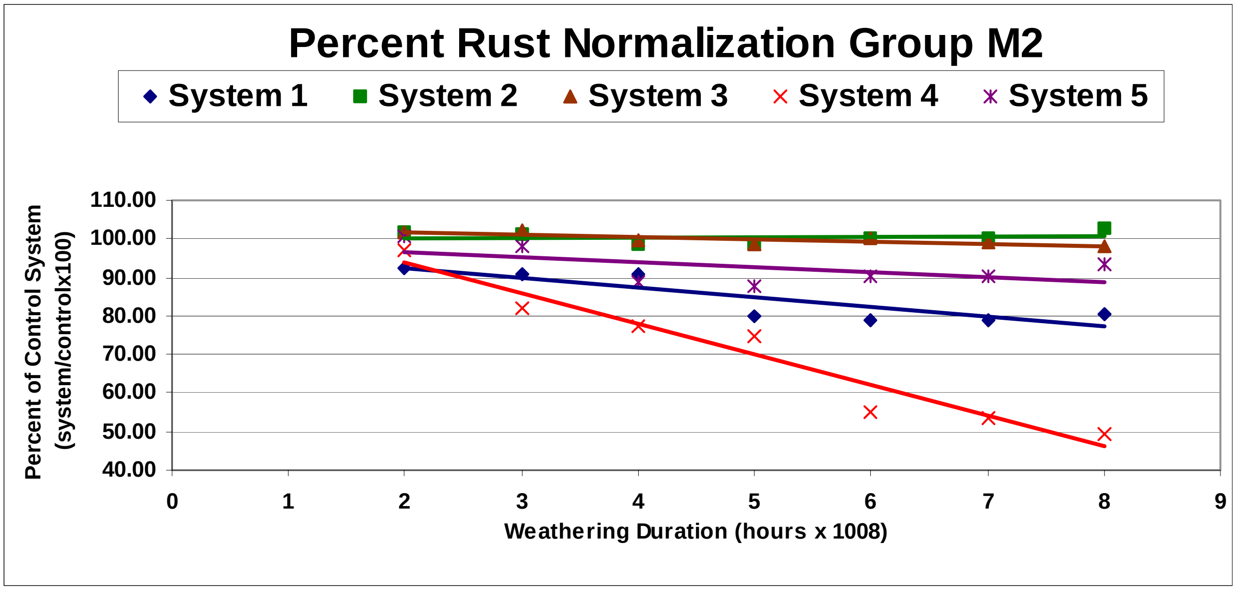

Figure 13. Percent rust normalization curves for coatings systems from manufacturer M2 based upon performance on the control system.

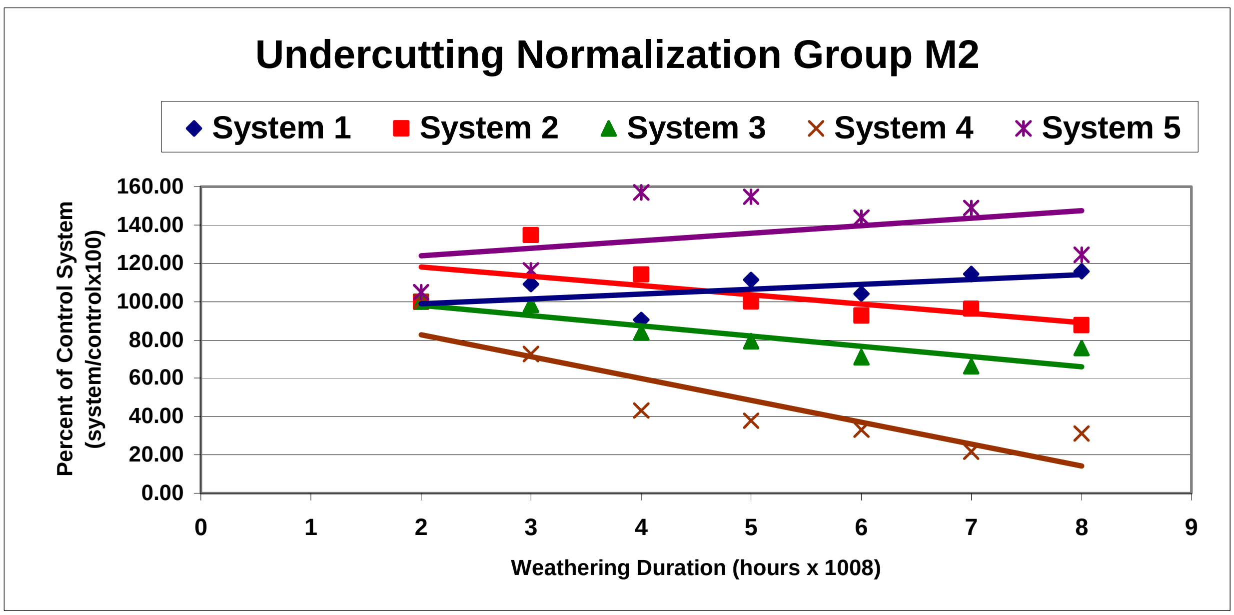

Figure 14. Scribe undercutting curves for coatings systems from manufacturer M2 based upon performance on the control system.

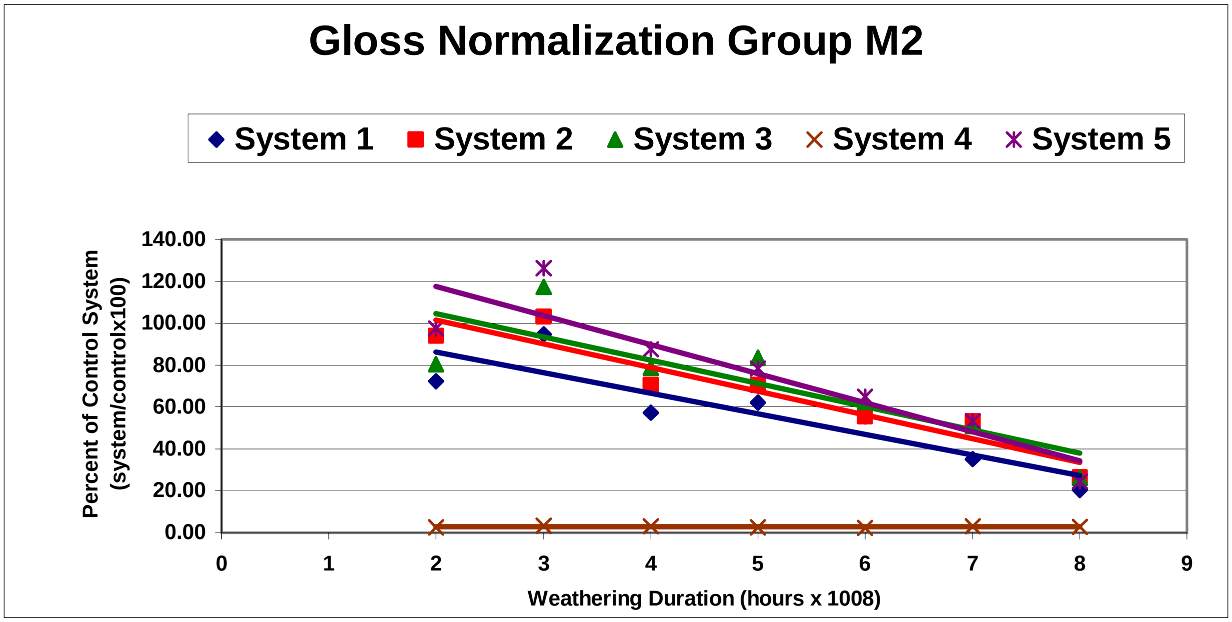

Figure 15. Gloss normalization for coatings systems from manufacturer M2 based upon performance on the control system.

Figure 16. Applying MIO pigmented MCU primer/intermediate coating at the KYTC steel bridge yard in Frankfort in 1999.

Figure 17. Inspecting inorganic zinc primer for micro-cracking at a steel fabrication shop in 1998. Subsequent spot rusting of completed paint system (including intermediate and top coats) shown in 1999 (insert).

Figure 18. Applying experimental organic zinc topcoat at manufacturer's plant in 1999.

Figure 19. Using video microscope to examine organic zinc coatings for micro-defects in 1999.

Figure 20. Applying experimental organic zinc coating to blast cleaned beam at the KYTC steel bridge yard in 1999.

Figure 21. Bayer personnel applying test patch of a) quick-curing organic zinc MCU primer (insert) and b) a topcoat of quick-curing acrylic PU in 2000.

APPENDICES

Appendix A: US 119 Bridge Over Cumberland River In Bell County

FD52 007 0119 000-001

Background

On October 28, 1998 a contract was awarded for the experimental cleaning and painting of the US 119 Bridge {BRO 119-1 (23)} over Cumberland River in Bell County and the construction and painting of a companion bridge to provide four lanes of traffic (1). The total contract award was for a lump sum of $3,182,862.35. The focus of the experimental monitoring was the maintenance painting of the existing bridge.

Special Notes

The Contract for this project included Special Notes for:

- Pressure Washing, Mechanical Surface Preparation, And Paint Application,
- Paint,
- Polyurethane Paint System Used For Maintenance Overcoating Applications,
- Quality Control,
- Environmental And Worker Safety Regulations, and
- Project Monitoring.

In addition to the listed special notes the contract required that all work be done in accordance with the Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, Section 615 Maintenance Cleaning and Painting Steel Bridges.

The special note for washing, mechanical surface preparation, and painting required total enclosure of the structural steel during all phases of the work. Containment screens were employed to trap all loose solid debris generated during the washing and mechanical surface preparation operations. That special note also required the use of new containment screens with 85 % (minimum) mesh. In addition to containment screens, this special note required the use of a filter fabric consisting of a polypropylene; non-woven, needle-punched geotextile or equivalent attached to the containment screens to filter all waste wash-water. The filter fabric had an apparent opening size of 430 microns. The contractor was required to provide a written manufacturer’s certification that all screens and filter fabric met the project specifications.

Washing Specifications

The contract required that all structural steel be cleaned by pressure washing prior to mechanical surface preparation. The steel was to be washed at a minimum of 7,000 psi (at a minimum flow rate of 1.5 gallons per minute) with 0^o spinner nozzles. The wand nozzle was to be held a maximum of six (6) inches from the surface being pressure washed and approximately normal to the working surface. Additional cleaning (i.e., solvent, steam, or hand cleaning) were required if pressure washing did not sufficiently clean the steel.

Cleaning Specifications

The contractor was required to perform mechanical surface preparation by power-tool cleaning on all surfaces not possessing clean, adherent paint. Power-tool cleaning of those surfaces was to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3

Visual Standards for Power- and Hand-Tool Cleaned Steel. On this project, an SSPC VIS3-SP11 surface condition was specified for mechanically cleaned surfaces.

Painting Specifications

The existing bridge was to receive three coats of paint. That included a full prime coat of aluminum-pigmented moisture cure polyurethane to be brushed on at 2.0 to 3.0 mils dry film thickness (DFT), an intermediate coat of MIO-pigmented moisture cure polyurethane to be applied by brushing, rolling or spraying (at the option of the contractor) at 3.0 to 5.0 mils DFT, and a two-component finish coat of aliphatic acrylic polyurethane to be applied by brushing, rolling or spraying at 2.0 to 3.0 mils DFT.

Observations During the Project

The prime contractor began fieldwork on February 17, 1999. On July 18, 1999 members of the KYTC Paint Team met with the KYTC inspectors and the contractor’s painting personnel at the job site for the specified test patch application. The contractor wanted to begin work at that time, but had several requirements to meet before he could begin. The inspectors prepared a list of those requirements including: preparation of a proper hazardous waste storage area, establishing proper traffic control, acquiring line pressure loss charts for his pressure washing equipment, procuring the necessary SSPC visual standards, and acquiring a project log book.

The project involved building a new bridge besides the existing one to accommodate four lanes of traffic. A second test patch was applied to the new bridge on August 8, 2000 as it employed a different paint system. Painting operations on both structures were conducted concurrently. Painting operations seemingly progressed satisfactorily and KTC researchers did not monitor the project until the final inspection.

The final inspection was conducted on June 19, 2000. Most of the work was deemed satisfactory. The inspection revealed pinholes, cracks, blisters, runs, and misses that were to be eliminated as part of a corrective work punch list.

Final Inspection Report

Comments from final inspection report were as follows: “The Departments “Snooper” truck was used for the inspection. All work inspected appears to have been completed within reasonable close conformance of the Standard Specifications and Special Notes applicable to the project except as noted on the next page” (i.e. the corrective work punch list).

Summary

The Special Notes and Standard Specifications were not followed entirely during the cleaning and painting of bridge. Lifted edges of overcoated paint and rust in Tooke cuts indicated that an SP11 surface finish was not obtained during cleaning of bridge. There should have been no rusted substrates when the new coatings were applied and exposed edges of existing paint should have been feathered to prevent lifting.

While the work on this project was accepted, it was not entirely in conformance with the Standard Specifications and Special Notes. While the lifted edges could be located and identified, it would be difficult to locate and repair areas where coatings had been applied over rusted substrates.

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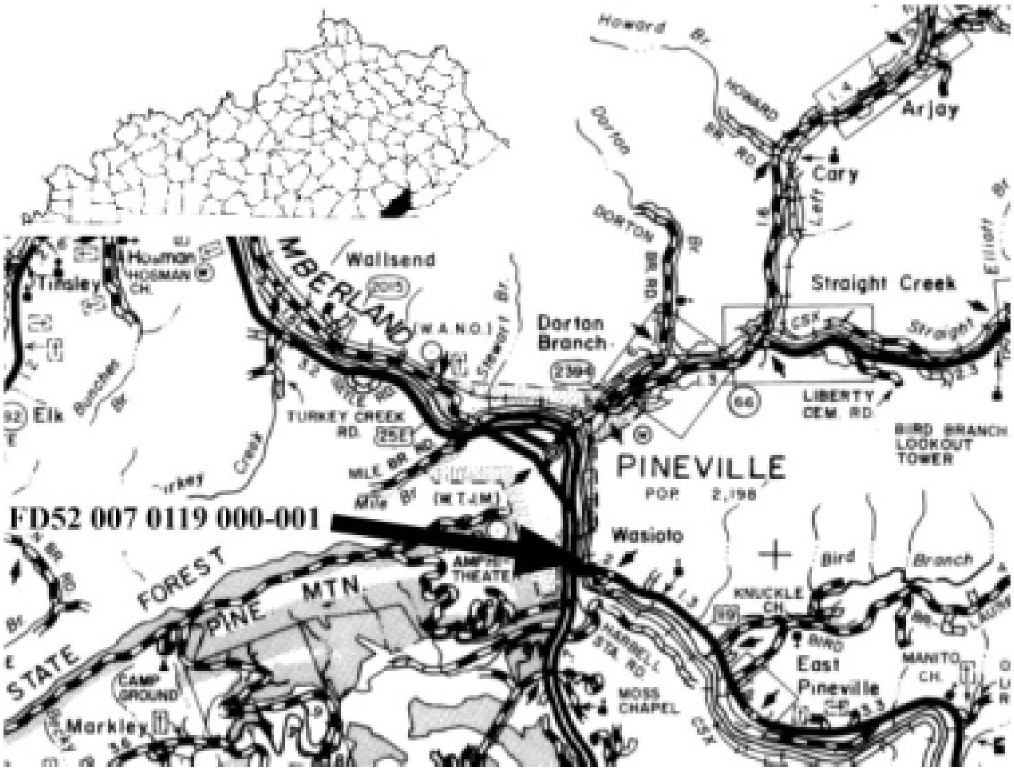

Figure 22. A location map of the US 119 Bridge Over the Cumberland River in Bell County.

Figure 23. The hazardous waste storage site for the US 119 Bridge.

Figure 24. The condition of north face of the existing bridge prior to the onset of work.

Figure 25. The test patch surface completely prepared for paint application.

Figure 26. A painter applying the primer on the paint test patch.

Figure 27. A painter using a tooth gage to measure the wet film thickness of the primer.

Figure 28. Use of a Tooke scratch gage to measure the dry film thickness on the intermediate coat.

Figure 29. A painter applying the top coat to the paint test patch.

Figure 30. A worker feathering of exposed edges of existing paint with putty knife.

Figure 31. The completed experimental coating during the final inspection of the bridge.

Appendix B: US 25 Bridge Over I-75 In Fayette County

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Background

On October 28, 1999, a contract was awarded for the experimental cleaning and painting of the US 25 Bridge (B00008) over Interstate 75 in Fayette County. This bridge is a steel deck girder structure with two 66-foot and two 94-foot spans. The bridge possessed (approximately) 17,265 ft^2 of steel surface area to be painted. The contract award was for a lump sum of $94, 500.

The existing coating included a red-lead primer with one coat of leafing aluminum intermediate and one coat of nonleafing aluminum top coat. The existing coating was severely deteriorated with rust on 15-20 % of the surface.

Special Notes

The Contract for this project included Special Notes for:

- Pressure Washing, Mechanical Surface Preparation, And Paint Application,
- Paint,
- Polyurethane Paint System Used For Maintenance Overcoating Applications,
- Quality Control,
- Environmental And Worker Safety Regulations, and
- Project Monitoring.

In addition to the listed special notes the contract required that all work be done in accordance with the Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, Section 615 Maintenance Cleaning and Painting Steel Bridges.

The special note for washing, mechanical surface preparation, and painting required total enclosure of the structural steel during all phases of the work. Containment screens were employed to trap all loose solid debris generated during the washing and mechanical surface preparation operations. That special note also required the use of new containment screens with 85 % (minimum) mesh. In addition to containment screens, this special note required the use of a filter fabric consisting of a polypropylene, non-woven, needle-punched geotextile or equivalent attached to the containment screens to filter all waste wash-water. The filter fabric had an apparent opening size of 430 microns. The contractor was required to provide a written manufacturer's certification that all screens and filter fabric met the project specifications.

Washing Specifications

The contract required that pressure washing be used to clean all structural steel. The steel was to be washed at a minimum of 7,000 psi with 0^o spinner nozzles. The wand nozzle was to be held a maximum of six (6) inches from the surface being pressure washed and approximately normal to the working surface. Additional cleaning (i.e., solvent, steam, or hand cleaning) were required if pressure washing did not sufficiently clean the steel.

Cleaning Specifications

The contractor was required to perform mechanical surface preparation by power-tool cleaning on all surfaces not possessing clean, adherent paint. Power-tool cleaning of those surfaces was to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3 **Visual Standards for Power- and Hand-Tool Cleaned Steel**. On this project, an SSPC VIS3-SP11 surface condition was specified for mechanically cleaned surfaces.

Painting Specifications

Painting of the bridge consisted of three coats. A full prime coat of aluminum-pigmented moisture cure polyurethane was to be brushed on at 2.0 to 4.0 mils DFT. One full intermediate coat of aluminum-pigmented moisture cure polyurethane was to be applied by brushing, rolling or spraying (at the option of the contractor) at 2.0 to 4.0 mils DFT. A finish coat of aliphatic acrylic polyurethane was to be applied by brushing, rolling or spraying one full coat at 2.0 to 4.0 mils DFT.

Observation During Project

The painting contractor moved on to the site on May 20, 2000. On May 22, 2000 members of the Paint Team met with the KYTC inspectors for the project and the contractor at the job site. The contractor was ready to begin work, but had several requirements to meet before beginning work. The inspectors prepared a list of requirements for the contractor to address work. These included but were not limited to; proper hazardous waste storage area, traffic control, line pressure loss charts, visual standards, and log book. The contractor stated that he intended to apply the primer and/or intermediate coat(s), then, leave the site to conduct work out of state and return to complete the project at a later date. He was informed that the coating had a recoat window of 5 days which if exceeded would require abrading the coating before application of subsequent coats. After heated discussion, the contractor elected to abandon the site and return at a later date.

The contractor returned to the job site on June 1, 2000 to begin work. He began work on the end spans (Spans 1 and 4). The Special Note for Cleaning required that any washed surface not having adherent paint be treated to a SSPC VIS3-SP 11 condition. SP 11 requires removal of all rust and mill scale of all existing coating. The contractor was permitted to leave mill scale that was not corroded. After the primer and intermediate coats were applied, Tooke tests revealed the presence of rust in several areas where no previously existing coating remained. The contractor was required to remove all rust on the structural steel.

A final inspection of Spans 1 and 4 revealed pinholes, cracks, and bubbles over most of both spans. Tooke readings disclosed excessive thickness of the intermediate coat.

Final Inspection Report

Comments from final inspection report were as follows: "All work inspected was not completed within conformance of the Standard Specifications and Special Notes applicable to this project. The structural steel over I-75 was cleaned and painted within conformance of the Specifications and Special Notes. On both end spans, the cracked, blistered and bubbled paint that was applied was not repaired and repainted as directed. The debris on the easternmost abutment was not removed as directed. As of this date (6-29-00), the hazardous waste manifests from the hazardous waste facility have not been received by this office (Division of Construction). Please do not release any of the remaining funds on this project until the above conditions have been corrected."

At times, the traffic control during the course of this project was improper. On the southbound I-75, the tarps were observed to be blowing into the traffic lane while the contractor was painting over the passing lane. In another case, no traffic control or proper signs were posted to warn the motorists about stoppage of traffic when the contractor was moving his truck over the I-75 northbound lane from span to span to continue with painting operations.

The work done in the spans adjacent to the abutments was not completed within conformance of the Standard Specifications and Special Notes. The cleaning and painting over the roadway of I-75 was done within general conformance to the Specifications and Special Notes.

Follow On Inspection

Post-completion inspections of spans 1 and 4 were conducted on July 28 and August 1, 2000. Those were conducted from the ground. Therefore access to the painted surface was limited to approximately 15 feet from the abutment(s) on the side spans.

Span 1

Beam 1

East End Pinholes with red lead visible, blisters and bubbles were not sanded but had been top coated. Dry film thickness (DFT) measurements indicated 2 mils of primer, 4 mils of intermediate coating, and 3 mils of topcoat.

West End Tooke cuts revealed rust under the overcoated paint. Pinholes were observed in the topcoat.

Beam 2

East End Sanded areas were not top coated. Pinholes, blisters, bubbles, and cracks were present on the web and diaphragm. DFT measurements indicated 2 mils of primer, 4 mils of intermediate coating, and 2 mils of topcoat.

West End Areas of pinholes on web and diaphragm, minor cracks with red lead visible.

Beam 3

East End Sanded areas were not top coated. Pinholes, blisters, bubbles, and cracks were detected on the web and diaphragm.

West End Sanded areas were not top coated. Pinholes, blisters, bubbles, and cracks were detected on the web and diaphragm.

Beam 4

East End Sanded areas were not top coated. Pinholes, blisters, bubbles, and cracks were present on the web and diaphragm.

West End Sanded areas were not top coated. Pinholes, blisters, bubbles, and cracks were present on the web and diaphragm.

Beam 5

East End Sanded areas were not top coated, pinholes with red lead were present on the web. Cracks, bubbles and blisters were present on the web and diaphragm, Tooke cut with visible red lead, about 3ft^2 of asphalt spatter was present on the paint near the abutment.

West End Pinholes, blisters, bubbles and cracks were present on the web and diaphragm, lifted edges were present on diaphragm with red lead visible, the bottom flange edge of the beam has scars and red lead visible. DFT measurements indicated 2 mils of primer, 4 mils of intermediate coating, and 6 mils of topcoat.

Span 4

Beam 1

East End Numerous pinhole areas were present, topcoat was missing on bolts at a rocker and on the backside of abutment diaphragm (3).

West End Pinholes and bubbles were present throughout. DFT measurements indicated 4 mils of primer, 3 mils of intermediate coating, and 6 mils of topcoat.

Beam 2

East End Numerous sites with pinholes, lifted edges were present at the diaphragm. Portions of the stringer and diaphragm had been sanded but not top coated.

West End Poor surface preparation, lifted edges of old paint, visible red lead were observed in web-to-bottom corner of the flange. Several Tooke cuts had been made prior to touch-up – two of which were not properly touched-up. Red lead and steel were visible in the Tooke cut.

Beam 3

East End Sanded areas on web of stringer and diaphragm had not been top coated, some areas have been sanded into the intermediate coat. Numerous cracks and blisters have been top coated without being sanded. Red lead is visible across length of angle of the abutment diaphragm at bottom corners and appears to have been scrapped and lightly top coated.

West End Cracks with red lead are visible in top and bottom of web. Tooke cuts are un-repaired with visible red lead, lifted edges on diaphragm at abutment. Sanded areas without topcoat were also present.

Beam 4

East End Bubbles and cracks in areas of web have not been sanded or touched-up. Cracks can be seen through topcoat. The top edge of bottom flange has exposed red lead. DFT measurements indicated 4 mils of primer, 3 mils of intermediate coating, and 6 mils of topcoat.

West End Deep cracks were present, running through topcoat in web. Bubbles, blisters, and cracks were present on the web and diaphragm. These locations have been top coated but not sanded. Other areas have been sanded, but not top coated.

Beam 5

East End Small sanded areas were not touched-up.

West End Areas on web and diaphragm were sanded but not touched-up. Areas on web and diaphragm, with cracks and bubbles were not sanded or touched-up.

Summary

The Special Notes and Standard Specifications were not followed throughout the cleaning and painting of this bridge. Lifted edges of paint detected in Spans 1 and 4 indicate that the specified SP11 cleaning was not obtained. Rust detected in Tooke cuts also indicates that cleaning of bridge was not performed properly.

The follow-on inspection of Spans 1 and 4 revealed pinholes, cracks and bubbles over most steel in both spans. Those areas were noted in the final inspection but were not corrected. Tooke tests indicated excessive thickness of the topcoat in two areas. There were many areas with visible red lead. As a consequence of the contractor's failure to follow the contract requirements, this project is not in conformance with the Special Notes and Standard Specifications.

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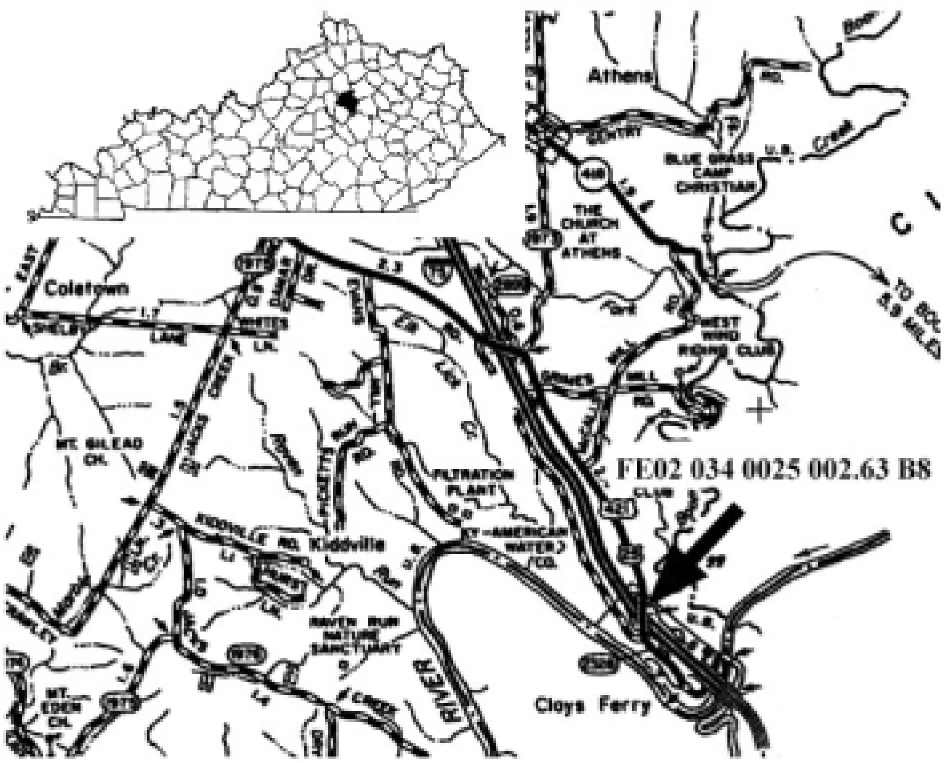

Figure 32. Location map of the US 25 bridge over I-75 in Fayette Co.

Figure 33. The north-facing view of the US 25 Bridge over I 75 in Fayette County.

Figure 34. The condition of the existing paint on the bridge prior to painting operations.

Figure 35. The back face of an abutment diaphragm showing a lack of topcoat.

Figure 36. Pinholes and bubbles were observed in the new coating throughout the bridge.

Figure 37. Lifted edges of existing paint at a diaphragm.

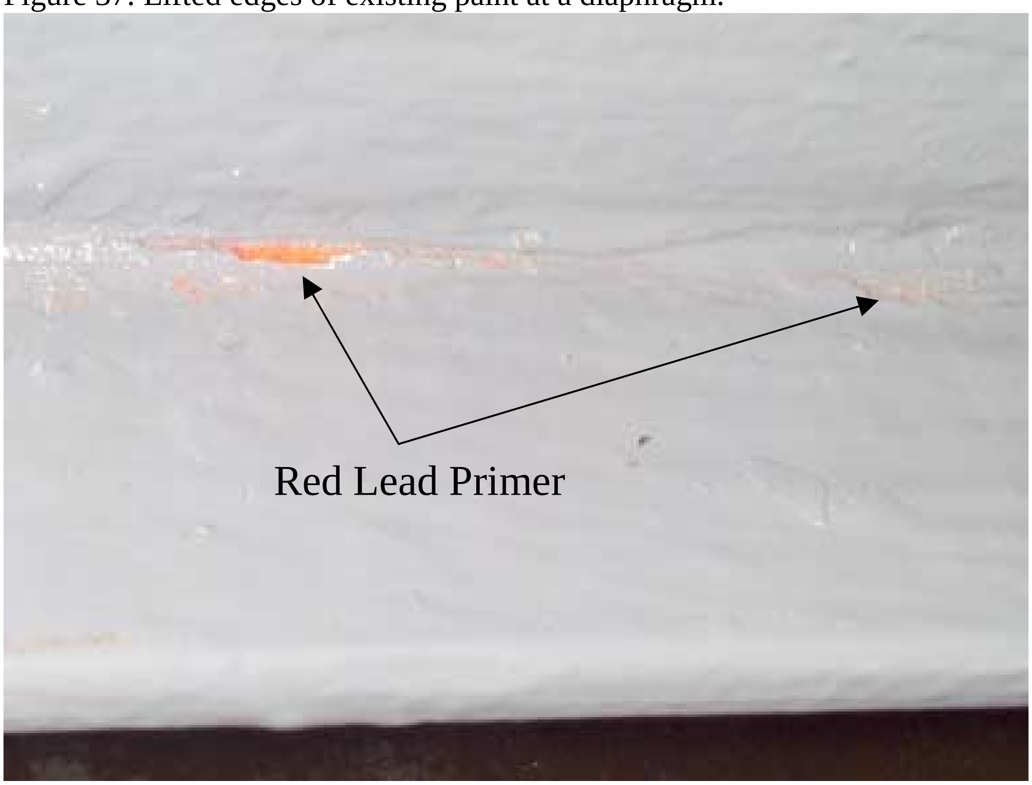

Figure 38. Exposed red lead on an abutment diaphragm.

Figure 39. Exposed red lead and a lifted paint edge at the corner of a bottom flange.

Appendix C: KY 88 Over Rock Creek Embayment In Grayson County

FE 02 043-0088-011.04 (B8)

Background

On October 28, 1999, a contract was awarded for the experimental cleaning and painting of the KY 88 Bridge (bridge no. 8 at mile point 11.04) over Nolin Reservoir in Grayson County. This bridge was a typical deck-girder bridge possessing two-126 ft. and three-157.67 ft. spans. It incorporated four steel girders and had approximately 65,000 ft^2 of steel surface. The contract award was for a lump sum of $143,000.

The most recent maintenance painting work on that structure had been performed in 1990, using complete removal of the existing coating by open abrasive blasting. The Natural Resources and Environmental Protection Cabinet stopped the project as the open blasting allowed an environmental release of a hazardous material, lead, contained in the existing coatings. Site remediation was required and, although the work was only about 50 percent complete, KYTC did not attempt to re-paint the bridge until this experimental project was initiated. The existing coating on approximately half the bridge prior to the abrasive blasting operation included a red-lead primer, an aluminum intermediate, another coat of red lead with lamp black and an alkyd top coat. The second coat of red lead indicates that the bridge had been previously over coated. The existing coating that was applied after the abrasive blasting operation consisted of one coat of zinc primer and one coat of vinyl topcoat.

Special Notes

The Contract for this project included Special Notes for:

- Pressure Washing, Mechanical Surface Preparation, And Paint Application,
- Paint,
- Polyurethane Paint System Used For Maintenance Overcoating Applications,
- Quality Control,
- Environmental And Worker Safety Regulations, and
- Project Monitoring.

In addition to the listed special notes the contract required that all work be done in accordance with the Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, Section 615 Maintenance Cleaning and Painting Steel Bridges.

The special note for washing, mechanical surface preparation, and painting required total enclosure of the structural steel during all phases of the work. Containment screens were employed to trap all loose solid debris generated during the washing and mechanical surface preparation operations. That special note also required the use of new containment screens with 85 % (minimum) mesh. In addition to containment screens, this special note required the use of a filter fabric consisting of a polypropylene, non-woven, needle-punched geotextile or equivalent attached to the containment screens to filter all waste wash-water. The filter fabric had an apparent opening size of 430 microns. The contractor was required to provide a written manufacturer's certification that all screens and filter fabric met the project specifications.

Washing Specifications

The contract required that pressure washing be used to clean all structural steel. The steel was to be washed at a minimum of 7,000 psi with 0^o spinner nozzles. The wand nozzle was to be held a maximum of six (6) inches from the surface being pressure washed and approximately normal to the working surface. Additional cleaning (i.e., solvent, steam, or hand cleaning) were required if pressure washing did not sufficiently clean the steel.

Cleaning Specifications

The contractor was required to perform mechanical surface preparation by power-tool cleaning on all surfaces not possessing clean, adherent paint. He was to power-tool clean those surfaces to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3 **Visual Standards for Power- and Hand-Tool Cleaned Steel**. For this project, SSPC VIS3-SP11 surface condition should have been present at time of painting.

Painting Specifications

Davis Frost Paint Mfg. was to supply the paint for this project, but due to the company terminating production of structural paint, Sherwin Williams Inc. became the paint supplier. Painting of the bridge consisted of three coats. A full coat of moisture cure aluminum primer was to be brushed on at 2.0 to 4.0 mils DFT. One full intermediate coat of moisture cure micaceous iron oxide was to be applied by brushing, rolling or spraying at 3.0 to 5.0 mils DFT. A two-component polyurethane topcoat was to be applied by brushing, rolling or spraying one full coat at 2.0 to 3.0 mils DFT.

Observation During Project

The painting contractor moved onto the jobsite on April 3, 2000. The contractor began preparing a test patch area. The purpose of the test patch is for visual reference for the Quality Control Inspector (QC) and the Quality Assurance Inspector (QA) to refer to during the life of the project. On April 19, 2000 the painting of the test patch began. The prime coat was applied at 3.0 to 5.0 mils wet film thickness (WFT) by brushing. Later that afternoon, the intermediate coat was applied at 3.0 to 5.0 mils WFT by spraying. On April 20, 2000 the finish coat was applied at 2.0 to 4.0 mils WFT by spraying. The test patch was inspected and accepted. The contractor then proceeded to work toward completion of the project.

Thereafter, KYTC and Kentucky Transportation Center (KTC) personnel periodically monitored the progress of work on the structure due to its experimental nature. They inspected accessible portions of the contractor's work in progress and made photographic records of their findings. Those periodic inspections revealed a number of deficiencies in

the contractor’s work. Those problems included: 1) inadequate containment, 2) insufficient cleaning, 3) improper coatings application procedures, 4) painting over inadequately cleaned substrates, 5) improper waste storage procedures, and 6) numerous small-unpainted areas. A meeting was held between KYTC officials, the KYTC on-site inspectors and the contractor at the jobsite on May 3. At that time, the contractor was apprised of those deficiencies and told to improve them or face KYTC stoppage of the project. The contractor was required to profile the newly placed primer applied from the East span of the bridge and re-prime it according to specifications.
The contractor completed the project in mid-May

Final Inspection Report

On May 19, KYTC and KTC personnel inspected the completed project. Close access was provided using a “snooper” man-lift as the contractor had disassembled his cables and pick-boards. Tooke coating thickness measurements were 1.0-1.5 mils for the primer, 1.5-2.5 mils for the intermediate coat and 0.5-2.0 mils for the topcoat. Most coating measurements were less than specified. Spots where the topcoat had not been applied (“missed areas”) were observed throughout the structure. The topcoat was notably thin throughout most of the west span between the abutment and pier. The green-tinted primer was visible through the gray topcoat in that portion of the bridge. Locations were observed where the contractor had obviously painted over pack rust. KYTC officials required the contractor to repair all the deficiencies noted and re-spray the West span with topcoat.

After the painting work was completed, the contractor had three 55-gallon drums of hazardous wastes to be disposed of. He disposed of the wastes without properly informing KYTC officials. On the waste transporter’s manifest, only one of the drums was classified as hazardous solid waste. Division of Environmental Analysis officials could not ascertain the status of the other two drums

Follow-On Monitoring/Findings

KYTC Central Office officials were concerned that the contractor had not properly affected repairs to the KY 88 Bridge because the day following the final inspection, he moved his operation to Fayette County to begin work on the US 25 Bridge. As a consequence, KYTC and KTC personnel conducted a follow-up inspection of the KY 88 Bridge. A snooper and traffic control were provided on June 19 for the follow-on inspection. Starting on the West span, KYTC and KTC inspected the bridge to determine the extent of the contractor’s compliance with KYTC instructions to repair defects in his workmanship. The inspection found that the topcoat on the West span had been re-sprayed. However, obvious topcoat missed areas were readily visible throughout the structure. Steel at most locations under deck joints possessed pack rust. At many of those locations, the contractor had not properly removed the pack rust. Instead, he painted over it. Pick-board cables had chipped the paint at several locations and those had not been repaired. Tooke readings were made at random locations throughout the bridge. The readings fluctuated from 1.0 to 5.0 mils DFT for the primer, from 1.0 to 4.0 mils DFT for the intermediate coat, and from 1.5 to 5.0 mils DFT for the topcoat. The workmanship was poor with many sags and runs in the topcoat.

Summary

The defects and poor workmanship encountered on this project were not serious when considered individually. Their frequency and extent throughout this bridge however sum up to, at best, a marginal product that should not be countenanced in the future. The fact that this was an experimental maintenance painting project using a new coating system warrant that it be considered a failure for the purposes of a proper evaluation of that system.

This project is unusual in that above the normal workmanship issues of inadequate surface preparation, coating misses, and improper coating thicknesses is the abysmal appearance of the finished product. It is fortunate that this bridge is in a remote area and will not be widely viewed by the public. Otherwise, it would provide a poor image of KYTC ability, concern and effectiveness to the general public.

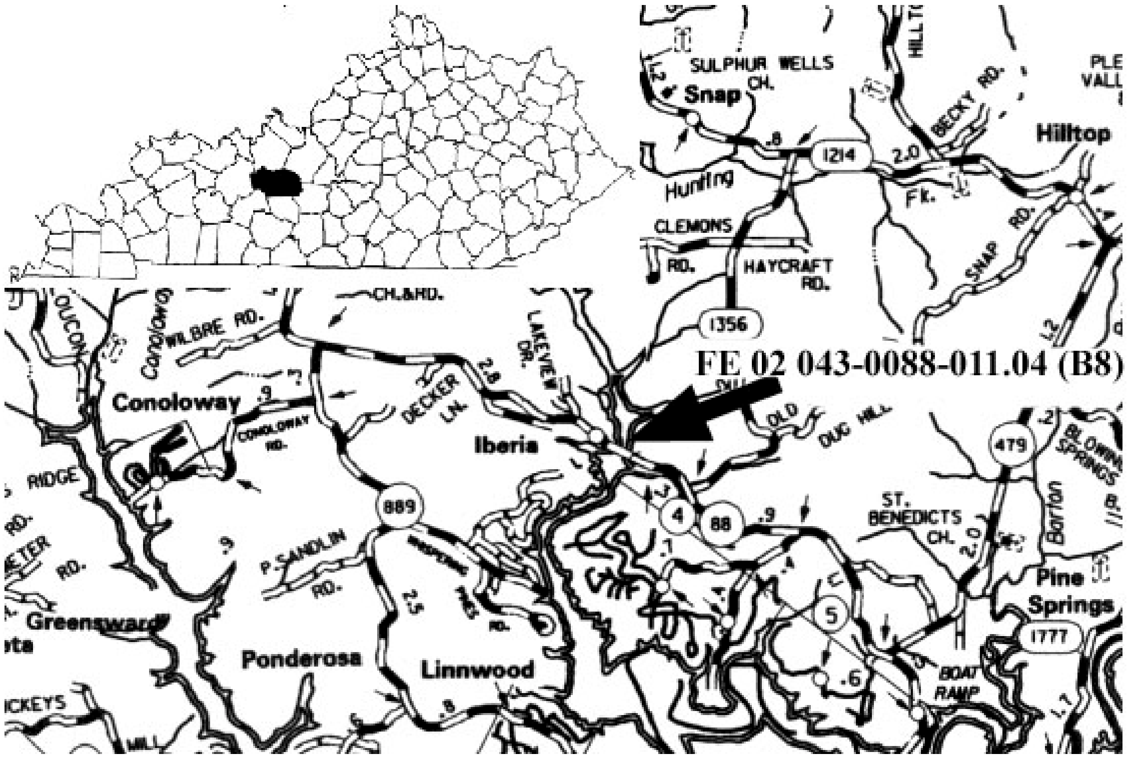

Figure 40. A location map of the KY88 Bridge over Rock Creek Embayment in Grayson County.

Figure 41. Looking at south side of bridge on KY 88 over Rock Creek Embayment in Grayson County.

Figure 42. The test patch area prior to paint application.

Figure 43. The test patch shown after it was completed.

Figure 44. The hazardous waste storage site for the bridge painting operation.

Figure 45. An example of areas the contractor missed during painting operations.

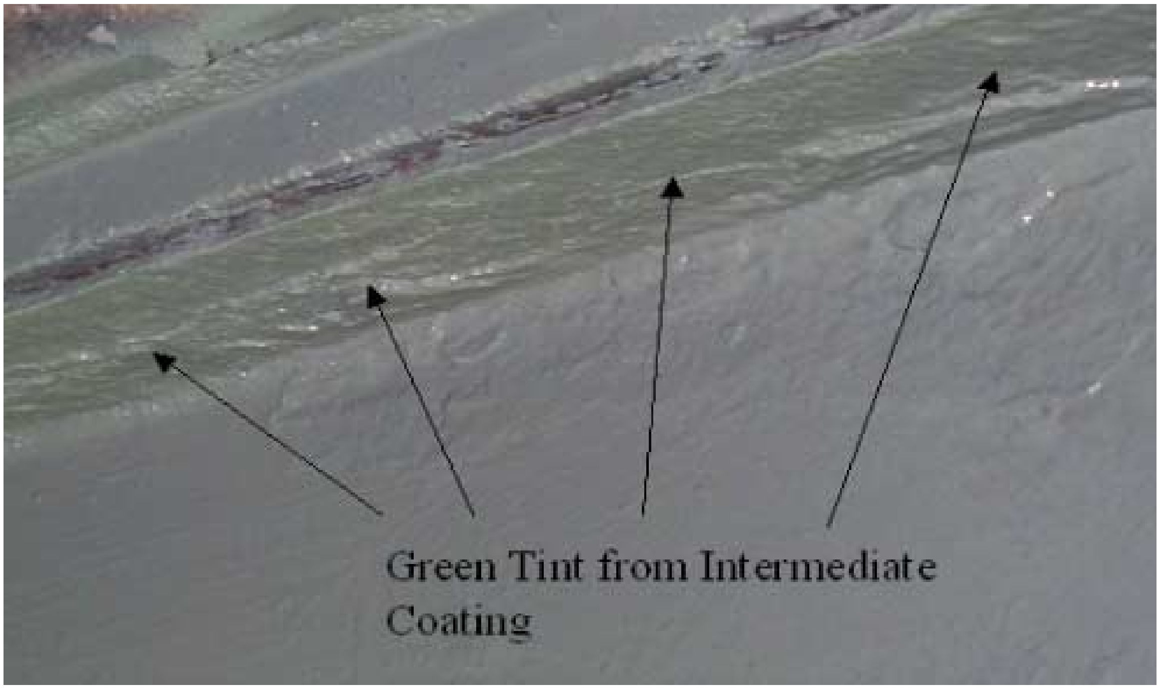

Figure 46. Green-Tinted intermediate coat visible through a thinly applied topcoat.

Figure 47. A location where new paint had been applied over pack rust.

Appendix D: KY 453 Twin Bridges Over US 62 In Livingston County

FE 02 070 0453 002.81 (B43 & B43p)

Background

In October 1999 a contract was awarded for the experimental cleaning and painting of the KY 453 twin bridges over US 62 in Livingston County. Both bridges are continuous steel-girder structures with two 60.5-foot spans and one 95-foot span. Together, they possess approximately 21,860 ft^2 of steel surface. The contract award was for a lump sum of $93,400.

The existing coating included a 615D red-lead primer with one coat of 615D with lamp black intermediate and one coat of nonleafing aluminum topcoat. The existing coating was very brittle and dirty with very little rust.

Special Notes

The Contract for this project included Special Notes for:

- Pressure Washing, Mechanical Surface Preparation, And Paint Application,
- Paint,
- Polyurethane Paint System Used For Maintenance Overcoating Applications,
- Quality Control,
- Environmental And Worker Safety Regulations, and
- Project Monitoring.

In addition to the listed special notes the contract required that all work be done in accordance with the Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, Section 615 Maintenance Cleaning and Painting Steel Bridges.

The special note for washing, mechanical surface preparation, and painting required total enclosure of the structural steel during all phases of the work. Containment screens were employed to trap all loose solid debris generated during the washing and mechanical surface preparation operations. That special note also required the use of new containment screens with 85 % (minimum) mesh. In addition to containment screens, this special note required the use of a filter fabric consisting of a polypropylene, non-woven, needle-punched geotextile or equivalent attached to the containment screens to filter all waste wash-water. The filter fabric had an apparent opening size of 430 microns. The contractor was required to provide a written manufacturer's certification that all screens and filter fabric met the project specifications.

Washing Specifications

The contract required that pressure washing be used to clean all structural steel. The steel was to be washed at a minimum of 7,000 psi with 0^o spinner nozzles. The wand nozzle was to be held a maximum of six (6) inches from the surface being pressure washed and approximately normal to the working surface. Additional cleaning (i.e., solvent, steam, or hand cleaning) were required if pressure washing did not sufficiently clean the steel.

Cleaning Specifications

The contractor was required to perform mechanical surface preparation by power-tool cleaning on all surfaces not possessing clean, adherent paint. He was to power-tool clean those surfaces to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3 **Visual Standards for Power- and Hand-Tool Cleaned Steel**. For this project, SSPC VIS3-SP11 surface condition should have been present at time of painting.

Painting Specifications

Painting of the bridge consisted of three coats. A full coat of moisture cure polyurethane penetrating sealer primer was to be brushed or sprayed on at 2.0 to 4.0 mils DFT. One full intermediate coat of MIO-pigmented moisture cure polyurethane intermediate coating was to be applied by brushing, rolling or spraying at 2.0 to 4.0 mils DFT. A two-component polyester topcoat was to be applied by brushing, rolling or spraying one full coat at 2.5 to 3.5 mils DFT.

Observation During Project

The painting contractor moved on site March 29, 2000 and began preparing a test patch area. The purpose of the test patch is for visual reference for the Quality Control Inspector (QC) and the Quality Assurance Inspector (QA) to refer to during the life of the project. On April 3, 2000 the painting of the test patch began. Rain in the morning postponed the application of the prime coat until mid-afternoon. The prime coat was applied at 3.0 to 5.0 mils wet film thickness (WFT). On April 4, 2000 the prime coat had cured to the satisfaction of the KYTC Paint Team members that were present. The intermediate coat was then applied at 5.0 to 8.0 mils WFT. After waiting approximately 5 hours the intermediate coat had cured so that the finish coat could be applied. The finish coat was then applied at 4.0 to 5.0 mils WFT. The contractor then proceeded to work toward completing the project.

During the final inspection it was noted there was areas of the bridge that had a dull finish and other areas with a glossy finish. At this time, the cause for this problem has not been identified.

Final Inspection Report

Comments from final inspection report were as follows: “All work inspected appears to have been completed in substantial conformance of the Standard Specification and Special Notes applicable to the project. Corrective work requested: Stencil project number and date painted on both structures. Remove hazardous wastes properly and provide the Resident Engineer with the manifests.”

After the corrective work was finished, the project was accepted as complete on June 6, 2000.

Summary

The Special Notes and Standard Specifications were followed throughout the cleaning and painting of bridges B00043 & B00043P. Most areas possessed an SP11 surface preparation prior to application of the new coatings. All three coats of paint were applied within the specified limits. All work inspected was completed in conformance of the Standard Specifications and Special Notes for this project.

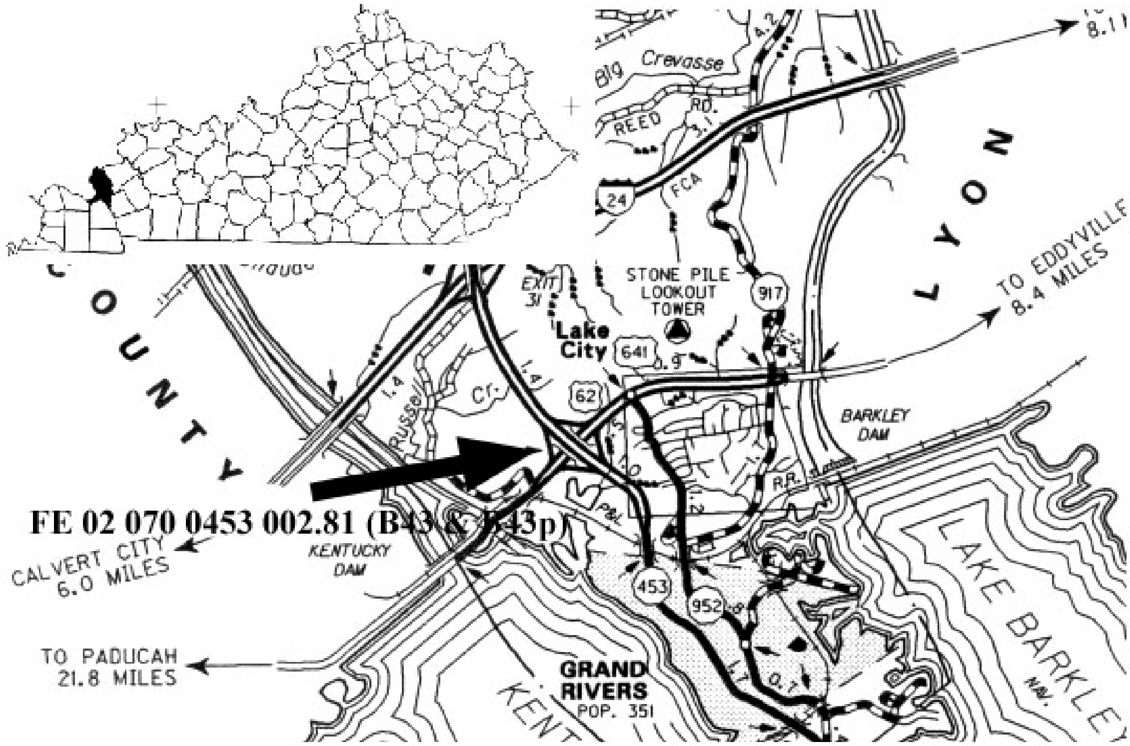

Figure 48. A location map of the KY 453 twin bridges over US 62 in Livingston Co.

Figure 49. An eastward view of the KY 453 twin bridges over US 62 in Livingston Co.

Figure 50. The condition of the existing coating prior to painting operations.

Figure 51. The test patch area after cleaning and surface preparation.

Figure 52. A painter applying topcoat to the test patch.

Figure 53. The mottled appearance of the topcoat alternating between flat and glossy finishes.

Appendix E: The Grand River Road (KY 453) Bridge Over The Barkley

Canal In Lyon County

FE02 072 0453 000.01

Background

On September 1, 1999 a contract was awarded for the experimental cleaning and painting of The Grand River Road (KY 453) Bridge over the Barkley Canal in Lyon County. The contract award was for a lump sum of $444,000.

KYTC Paint Team members conducted initial field inspections of the existing coatings. Tooke tests revealed an original coating on the bridge included 4 mils of red-lead primer with 0.5 mils of aluminum topcoat. That paint had been previously overcoated with approximately 2.5 mils of 615D lead based primer and 0.5 mils of gray alkyd topcoat. The low thicknesses of alkyd topcoats were obviously the result of weathering. The existing coatings were severely deteriorated with 15-20 percent surface rust.

Special Notes

The Contract for this project included Special Notes for:

- Pressure Washing, Mechanical Surface Preparation, And Paint Application,
- Paint,
- Polyurethane Paint System Used For Maintenance Overcoating Applications,
- Quality Control,
- Environmental And Worker Safety Regulations, and
- Project Monitoring.

In addition to the listed Special Notes the contract required that all work be performed in accordance with the Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, Section 615 Maintenance Cleaning and Painting Steel Bridges.

The Special Notes for pressure washing, mechanical surface preparation, and paint application required total enclosure of the structural steel during all phases of the work. Containment screens were intended to trap all loose solid debris generated during the washing and cleaning operations. The specifications required new containment screens with a minimum 85 % mesh. The note also added the possible requirement of 100% screens to contain paint overspray. In addition to containment screens, this project required the use of a filter fabric consisting of a polypropylene, non-woven, needle-punched geotextile or equivalent attached to the containment screens to filter all waste wash-water. The filter was specified to be a non-woven fabric with an apparent opening size (AOS) of 430 microns.

Washing Specifications

The contract required pressure washing to clean that all structural steel. The steel was to be washed at a minimum of 7,000 psi with 0^o spinner nozzles. The wand nozzle was to be held a maximum of six (6) inches from the surface being pressure washed and approximately normal to the working surface. Additional cleaning (i.e., solvent, steam, or hand cleaning) were required if pressure washing did not sufficiently clean the steel.

Cleaning Specifications

The contractor was required to perform mechanical surface preparation by power-tool cleaning on all surfaces not possessing clean, adherent paint. He was required to power-tool clean those surfaces to correspond with visual standards set forth in the Steel Structures Painting Council SSPC VIS-3 **Visual Standards for Power- and Hand-Tool Cleaned Steel**. For this project, SSPC VIS3-SP11 surface condition was specified at time of painting.

Painting Specifications

The experimental maintenance coating system used on this project had three coats. It consisted of: a full coat of yellow iron oxide pigmented moisture-cure polyurethane penetrating sealer to be applied by brushing or spraying at 1.0 to 3.0 mils DFT, one full intermediate coat of micaceous iron oxide (MIO) pigmented moisture-cure polyurethane applied by brushing, rolling or spraying (at the option of the contractor) at 2.0 to 4.0 mils DFT, and a two-component finish coat of gray polyester paint applied by brushing, rolling or spraying at 2.0 to 4.0 mils DFT. The contractor was required to prevent overspray and repair all defects in painting operation, such as pinholes, cracks, blisters, and runs.

Contractor Painting Operations

The painting contractor moved onto the site on September 23, 1999. On September 28, 1999 members of the KYTC Paint Team met with the KYTC inspectors for the project and the contractor at the job site for the test patch. At the pre-construction meeting, KYTC Paint Team members prepared a list of requirements for the contractor to address work. Those included but were not limited to**:** preparation of a proper hazardous waste storage area, traffic control, line-pressure loss charts, use of visual mechanical surface preparation standards, and acquisition and use of a project log book.

On September 29, three panels were washed as part of the test patch preparation. The contractor requested KYTC members for use of a fan tip nozzle on the pressure washer rather than the specified 0^o spinner nozzle for cleaning the test patch. This change was requested because the 0^o spinner nozzle got clogged. A demonstration of pressure washing with the 0^o spinner nozzle at 7,000 psi was done at an abutment the next day for KYTC members. The 100 percent containment used by the contractor was and well designed with impermeable side tarps discharging into 85% tarps covered with the filter fabric to properly contain all the wash water and ensure that it was properly filtered prior to discharge into Lake Barkley. KYTC Paint Team representatives checked the washed area of the test patch using a black rag/ white rag-wiping test and approved it for primer application. KYTC Paint Team representatives decided to allow the contractor to retain exposed mill scale substrates that were not corroded. The test panel was then sprayed with yellow-tinted primer at 6 to 8 mils wet film thickness (WFT). There was apparent separation of pigment in the paint at the edges as soon as it was sprayed on. Visual inspection using a 30X microscope revealed complete coverage of resin on the edges. As the only purpose of this coating was to provide a viable substrate for following coatings, the pigment separation was deemed acceptable. An intermediate coat of the MIO-pigmented moisture cure intermediate coating was spray applied at 6-8 mils WFT. KYTC Paint Team representatives approved the test patch and the contractor was permitted to proceed with painting of the bridge.

On October 10, 2000, the contractor had finished painting in the first bay and KYTC Paint Team representatives inspected and approved the work. At that time, the second bay was being power-tool cleaned and the third bay was being pressure washed. KYTC inspectors observed there was no extension of primer or intermediate coats where the primer/sealer and intermediate coats ended. As a consequence, they couldn't be properly overlapped when progressing the paintwork. Proper extensions of the primer/sealer and intermediate coats were required thereafter. During a subsequent visit to the site on October 27, 2000 work was progressing satisfactorily with all retouching work completed in the first bay.

The work progressed routinely after this last field inspection by the KYTC Paint Team. The bridge painting was completed on November 15, 1999.

Final Inspection

The final inspection of the bridge on November 15 revealed that all work was completed properly within general conformance of the Standard Specifications and Special Notes applicable to this project. Lifted edges of areas of paint were on Spans1 and 4 indicating that the SP11 surface preparation requirement was not always achieved during cleaning of bridge. Tooke tests revealed that the coating thicknesses were within the specifications.

Summary

The Special Notes and Standard Specifications were followed throughout the cleaning and painting of bridges. Most areas possessed an SP11 surface preparation prior to application of the new coatings. All three coats of paint were applied to meet the specifications of this project. All work inspected was completed within conformance of the Standard Specifications and Special Notes applicable to this project.

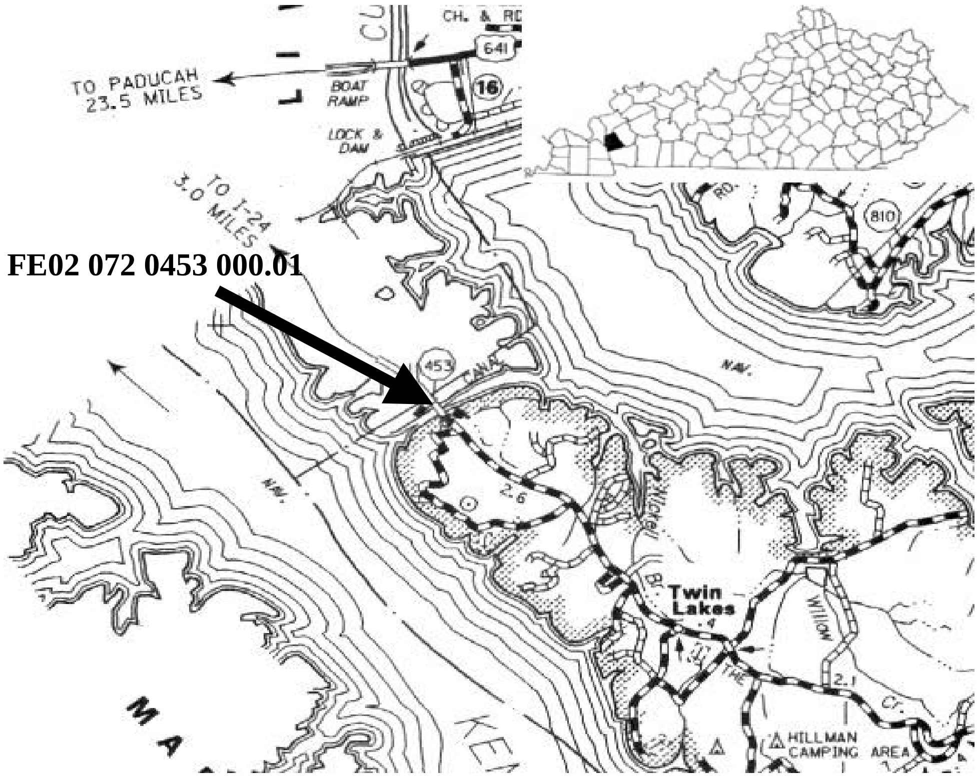

Figure 54. A location map of KY 453 Bridge over Barkley canal in Lyon Co.

Figure 55. Looking North at the KY 453 Bridge over Barkley Canal in Lyon County.

Figure 56. The first bay (South End) being pressure washed with 0^{o} spinner nozzle.

Figure 57. Test patch area power-tool cleaned to SSPC SP 11 standards.

Figure 58. The completed test patch application.

Figure 59. Blistering of the MIO intermediate coating during test patch application.

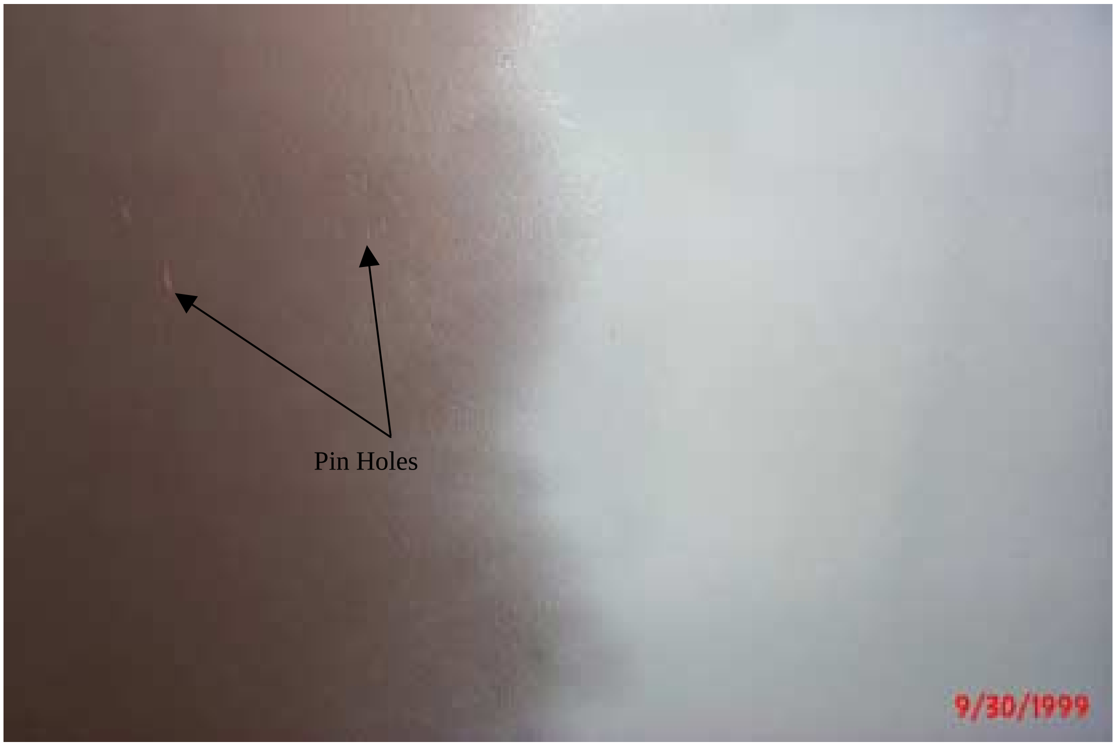

Figure 60. Pinholes in the intermediate coating after the test patch was applied.

Figure 61. Mill scale on steel exposed after pressure washing at 7,000 psi.

Figure 62. The hazardous waste storage site for the KY 453 Bridge.

Figure 63. Excessive paint applied to the to fasteners.

Figure 64. Inside of containment structure used for catching wash water and loose paint chips.

Figure 65. Visible swirl lines cut into the existing paint after pressure washing with a 0^o spinner tip